GEOLOGICAL SCIENCES
UNIVERSITY OF COLORADO BOULDER

Geology News

Editors:
Robert Anderson
Dan Mitchell

2023 - 2024

Chair's Corner

Robert Anderson

It is Spring Break 2023, and I thought I'd take a moment to craft a note for the newsletter before facing the crescendo of the end-of-school-year activities that will pounce upon all of us in the next month. As I am now in my 4th and final year of chairing the department, this will be my last newsletter. I will be handing over the reins of the department to the very capable hands of Anne Sheehan on July 1st. Let's do a quick review of the year.

Staff. We have again had a turnover in our staff. Happily, we are back to full strength with the arrival of Anne Marie Summers as the new office manager in summer 2022, and Josie Gray in fall 2022 as the new undergraduate program assistant. They are both rapidly learning the ropes. But I would be remiss if I were not to sing the praises of Marilynn and Kara. They have been with us for a while and have held us all together through the pandemic and all that has transpired around it. Their hard work keeps the department and our home the Benson Building in good shape.

Losses. This year was a tough one for the department in a couple of ways. While we seem to have dodged deaths attributed directly to COVID in our immediate family, we lost two to cancer this last year. We lost Peter Molnar, our star geophysicist and moral compass, early in the summer. He had just taken a trip to the Galapagos to revel in the geology and biology of that unique place with friends and family. Renowned worldwide for his 50 years of contributions to topics as diverse as plate tectonics, how mountains grow, and how ice ages come and go, he was known to us as someone with an unfailing emphasis on academic rigor, and an uncanny sense of justice. He lives on in that little whisper "What would Peter say?"

We also lost Sarah Crump to cancer. A recent Ph.D. who worked with Giff Miller, Sarah was a rising star. She had done her Ph.D. on Baffin Island climate history as seen through moraines and lake records. In her postdoc she was working to extract ancient DNA from sediment, keeping her on the cusp of paleoclimate research. She had just recently started as an assistant professor at the University of Utah. Her smile, her elegance, and her caring and daring way of going about life are missed sorely by all who knew her.

That the memories of both Peter and Sarah will endure is assured by the establishment of scholarships in their names. Both echo the depth of their humanity. Peter's family has established a scholarship fund to pay the tuition for undergraduate geology transfer students throughout their degree in our department. Sarah's family has established a summer fellowship for an underrepresented graduate student. Please see our website for details about these.

In the prior year, we also lost Pete Birkeland, an emeritus professor from our department who is known to many as one of the kings of soil science. The celebration of Pete Birkeland's life held last summer was lovely. The Benson Auditorium was packed with family colleagues and friends. All revelled in his accomplishments, from his skiing to his soil science. Pete was clearly one to wring the most out of life. That he did so with joy and a lot of humor was amply clear from the many stories that emerged!

Retirements. This year, as I step down as chair, two other faculty members will retire. Professor David Budd, long our carbonate stratigrapher and sedimentologist, and a strong advocate for high-quality teaching, will step into emeritus status. Distinguished Professor Giff Miller, a paleoclimatologist with an amazing record of research with strengths in both the glaciation of Baffin Island and the paleoclimate of central Australia and the demise of its huge birds, will step into emeritus status as well. We will miss their day-to-day wisdom but expect that they will stay engaged with the department for years to come.

In addition, Professor Paul Weimer has announced that he will retire at the end of the calendar year. With a long career in stratigraphy and its relevance for the petroleum industry, Paul ran for decades a consortium that supported graduate students training for careers in the petroleum industry. He has served as President of the AAPG and is presently the president of the American Geological Institute, with a focus on educational resources.

The present. So the department, which was 38 strong when I took the reins in 2019, will be 29 strong at the end of the year. We are a leaner and meaner department. As an aside, and for what it is worth, we will be 15 women and 14 men. I dare say that is likely a first for a large department in the geological sciences.

I took on the Chair duties in large part because I felt the newly hired faculty were a neat bunch, and I wanted to do what I could to support them as they climbed the tenure ladder. These faculty members are our future. They are indeed thriving. It has been a great pleasure to see Irina Overeem and Julio Sepulveda and Katie Snell get tenure (Katie this year!), and to see how smoothly Lizzy Trower and Carl Simpson passed through their reappointments (what we call the halfway mark on the tenure ladder). I fully

expect the same will be the case for Alisha Clark, Brad Markle, Carolyn Crow, and Shaily Rahman as they come up for reappointment in the next couple of years. Lizzy and Seb are up for tenure this coming year. As winners of a Sloan award, and an early career NSF award, respectively, they are perfectly poised to be promoted.

These four years have been quite the ride. We have dealt with COVID (or survived while it dealt with us). We have witnessed considerable reawakening associated with social injustice. As we have begun to re-emerge from COVID, we see that the world has changed. We can now all Zoom with the best. We have learned new teaching modes. The world is experiencing dramatically accelerating rates of climate change. We have plug-in cars… And the department is indeed a different place with the many retirements and losses, while the newer faculty are strapping in for the ride.

The future. It is high time to ponder what direction to go. It is in a new and rapidly changing world that we launch our students, undergrads, and grads alike. As I write, the Midwest is experiencing a tornado outbreak, the west coast is getting pummeled by a string of atmospheric rivers, the reservoirs, and lakes of the West are at their lowest levels in decades, sea level is rising at almost 4 mm/year, the NW passage is opening, and one of Europe's largest nuclear plants is deeply threatened in the Russian invasion of Ukraine. I could go on and on. Water resources are clearly being strained – too much here, too little there. We need tools to manage water, anticipate runoff from snowmelt, to enhance groundwater recharge. The world needs geological resources more now than ever. We need lithium for batteries, we need helium, we need rare earth elements for our electronics, and we need to bridge to that new greener world with smarter clearer use of traditional energy sources. We could also potentially pull CO_2 out of the atmosphere to hide it in geological formations. The hazards we face as climate changes are enhanced if not new. We need trained scientists to help identify and mitigate these new hazards. All citizens need to know these things, and it is our task to teach them. But look up as well. We also have a set of robotic rovers on the surface of Mars (some of them guided on a daily basis by members of our department), and astronauts are headed back to the Moon within the next couple of years for the first time since I was in college. We need to train the astronauts how to sample Moon materials properly. Beyond, the search for life that drives NASA missions to the moons of Jupiter and Saturn demands that we learn as much as we can from the early life on the one planet we know of that has supported life for billions of years – Earth.

So we are in the midst of rethinking our undergraduate curriculum. We teach all of this stuff. The earth sciences are the right place to engage in all of these issues. We have to sell our product better than we have and make the path through our major as efficient as possible, especially as many come to our major as transfer students. We are also involved in larger projects that go beyond our major. We are for example engaged in an effort to define an interdisciplinary Climate Minor that would be available to students from many science departments.

I was recently at a gathering of several past PhDs from our department, many of them engaged in local offices of government agencies like the Bureau of Reclamation and the USGS. It was heartening to hear stories of their involvement in the issues I have listed above, from the search for lithium in the playa-dotted valley floors of the West to the assessment of the best places to site new reservoirs, to the development of landslide and debris flow risk maps in the aftermath of forest fires, to the fast-response to earthquakes around the world. Our graduates are making a difference.

Thanks. Let me end with a note of thanks to our donors. I cannot emphasize enough how donations to this department improve our students' lives. Other departments in the Natural Sciences division of the College of Arts and Sciences have no such coffers. We have a growing number of fellowships to offer in recruiting the best and the brightest graduate students. We have a postdoctoral fellowship that will start next year. We have funds that are targeted to support under-represented students at undergrad and graduate levels. Additionally, we have gift funds that are not earmarked, which are therefore available as rainy-day funds to help a lab or a person or a program, or a course in need. We support our weekly all-hands gathering for coffee and donuts, a community-building event that I hope lives on forever, through such funds. I thank all who have contributed to the department at any and all levels.

So look to our website to keep track of these changes as we adjust to the new times. I wish you all well and thank you all for your support over the years.
Sincerely,
Bob Anderson

Cover Photo: Detail of the area called "cracked eggs" of the badlands in New Mexico's Bisti/ De-Na-Zin Wilderness. Channel sands in shallow marine silts of the Cretaceous seaway.
photo credit: Bob Anderson

Greetings from the Alumni Advisory Board

by Penny Patterson

Greetings from the Department of Geological Sciences Advisory Board. I am Penny Patterson, the newly elected Chair of the Advisory Board. For the past 13 years, the Advisory Board has been under the steadfast and exceptional leadership of Dean Miller. Dean has worked tirelessly to guide the Board and assist the Department on critical issues that arose over his tenure. He has been a strong advocate for the Department, especially through support of fundraising initiatives advanced by both the Department and the Advisory Board, and has been an advocate for the students through advising on curriculum revisions, and ensuring that students have access to critical resources and have a high-quality educational experience. We wish Dean much-deserved rest and relaxation on his many fishing adventures.

The Advisory Board has undergone some exciting new changes this past year. At the spring semester Board meeting, we welcomed two new Advisory Board Members, Nadine Reitman, and Mike Leibovitz. Nadine is a Research Geologist with the U.S.G.S Geologic Hazards Science Center in Golden, Colorado. She is currently conducting earthquake research including numerical modeling, field observations, and remote sensing to investigate how earthquakes are recorded in the landscape. Mike is a Geoscience Manager with Caerus Oil and Gas, LLC, and is currently directing exploration and production operations of natural gas in northwest Colorado and northeast Utah. In the fall, the Advisory Board Bylaws were amended to include Emeritus Board Members, who will be comprised of long-standing Advisory Board Members that would like to step down from their active role but would like to continue their engagement with the Board on a less demanding level. Dawn Kaback and Houston Kempton joined the Emeritus Board and are providing valuable contributions and insights to the Advisory Board.

In April, the Advisory Board held a Career Night event for the geology department students. Joe Zamudio was the primary driver behind Career Night and did an outstanding job. Joe organized the event, enticed the students to attend with a pizza dinner, and fostered excellent discussions on new geoscience career opportunities, critical networking techniques, and job-hunting strategies. The event was well received with several students contacting Advisory Board members regarding networking opportunities.

The geology department website is continually being updated and it has a wealth of information including videos of the colloquium talks, overviews of ongoing research programs in the department, articles about faculty members and their achievements, and contact information and brief biographies for the Advisory Board Members. I encourage everyone to visit the website; the address is https://www.cugeology.org.

In May, a celebration event was held by the university honoring Marcy and Bruce Benson and their contributions to the university and the geology department. The Bensons generously formed an endowment to support five Graduate Student Fellowships. These Fellowships have enabled the Department to recruit outstanding graduate students into the graduate program. The Advisory Board graciously thanks everyone for their contributions to the Department and the students.

In closing, the Advisory Board would like to extend our sincere appreciation to Bob Anderson, who will be rolling off as Chair of the Department of Geological Sciences at the end of June. Bob's tenure as Chair was exceptionally challenging with the quarantine of the CU Boulder campus during the COVID pandemic, disrupted and canceled funding initiatives, budgetary constraints, faculty retirements, and staff changes. Despite these challenges, the department has flourished under his leadership and continues to be ranked highly in the world in geosciences. The Advisory Board is deeply grateful for Bob's service and dedication to the geology department, faculty and staff, and the students. Finally, the Advisory Board extends a sincere thanks to Bob for facilitating an open and informative transition with Anne Sheehan, the incoming Department Chair, by inviting her to the spring Advisory Board meeting. We look forward to working with Anne as the Department Chair.

Geological Sciences Advisory Board Members

Eric Anderson
USGS

Lisa Campbell
Anschutz Exploration Company

Patricia Corbetta

Tim Farnham
Shell

Michael Leibovitz
Caerus Oil and Gas LLC

Harold Miller
Subsurface Consultants & Associates, LLC

Connor Newman
USGS

Shannon O'Dunn
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Penny Patterson - Chair
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Nadine Reitman
USGS

Sean Sundermann
Kilduff Underground Engineering

Charlie Wilson
Thornburg Investment Management

Joe Zamudio
Mineral exploration and remote sensing consultant

Anne Sheehan: Incoming Chair for the Department of Geological Sciences

by Janeddies Ramos Ríos and Karen Chin

Professor Anne Sheehan has led a very interesting and atypical life. She has been a geophysicist for more than 30 years and has tackled many complex questions about Earth's processes, often in remote corners of the world. But now she is embarking on a new adventure; stepping into the role as the new Chair of the Department of Geological Sciences at CU Boulder.

Anne was the 10th of 11 children in a family in which girls were expected to conform to traditional roles. However, while in high school she participated in science programs (sometimes in Colorado) and met Donald Steeples, a seismologist from the Kansas Geological Survey. Anne discovered that geophysics was a good fit for her because it had the perfect combination of geology, math, and physics. Don Steeples served as a mentor to Anne and offered her an internship when she finished high school. Her mom also supported her interest in science, but her father initially did not like her goal of being a scientist.

By the time Anne earned her bachelor's degree in geophysics at the University of Kansas in 1984, she had changed her father's mind and he was very proud of her. She subsequently earned a doctoral degree in geophysics at the Massachusetts Institute of Technology in 1991 and did a postdoc at Lamont Doherty Geological Observatory. Anne was offered a tenure-track job in the Department of Geological Sciences at the University of Colorado Boulder in 1993 and was happy to be back in the state she had visited in her youth. There were relatively few women geology professors at the time. At the time Mary Kraus was the only female professor in the department and the hiring of Anne Sheehan and Shemin Ge raised the number of women faculty members to three.

Anne has worked on many international research projects in geophysics. One of them was a large seismic experiment in Nepal. She said, "It was fascinating to fly into these very remote places." They used seismic recording equipment to study earthquakes and collect data. One member of her team was a graduate student who had worked for her as an undergraduate. They planned to train Nepalese to work on seismic stations so they would have to make fewer return trips. However, a week after they set up the stations, a civil war started in Nepal! Their stations were distributed throughout eastern Nepal and it was dangerous to collect data. Because of the civil war they always had to have a person from the Department of Mines of Geology, a guide (Sherpa), and their team. In fact, one of the stations was in the very village where the war first started.

Anne Sheehan fly flshing on the Blue River, CO in June, 2022

Anne also does research on board ships to deploy pressure sensors and ocean-bottom seismometers. The first time she went on an ocean research cruise, she saw the aurora australis (the southern lights) between Australia and Antarctica. "It was incredible; stunning!" There is a strict schedule on ships and crew members can have different shifts, usually lasting four to six hours. The ship has cabins for the people to rest and sleep. But the research crew does not cook, as research funding covers two cooks for the crew (about 40 people). Because of the constant movement of the ship, crew members usually put rubber underneath laptops and mugs so they do not roll away. Still, seeing the same big ocean, people, and meals can sometimes be boring. (Remember, during Anne's early research cruises, the internet was not widely available!) Doing research on a ship is not for everyone because people often get seasick. Nevertheless, Anne really enjoys being at sea.

One of Anne's recent papers is on tsunami warnings. This paper describes how tsunamis can be forecast using elevation and velocity data from commercial

ships at sea. However, this idea of using data from commercial ships to provide advance tsunami warnings cannot yet be utilized because ocean elevation data is not presently broadcast. There may be ways to get that data, however, and if this concept can be implemented people would have additional time to evacuate – depending on where the tsunami originates.

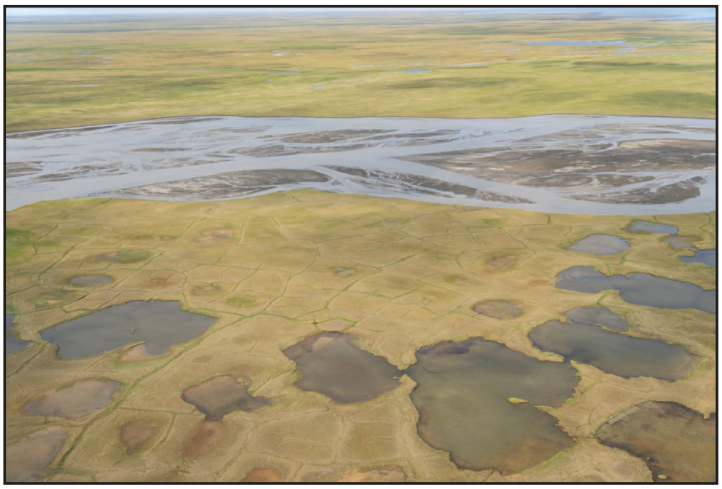
Anne Sheehan is a busy and award-winning geophysicist. She has imaged the mantle and continental crust, installed seismometers, used Distributed Acoustic Sensing, studied seismic tremors and slow slip, investigated induced seismicity, and worked on early warning systems for tsunamis. She does research, writes proposals, mentors graduate students and post-docs, teaches geology, and will soon become the new Chair of the Department of Geological Sciences at CU. She is also married to another geophysicist (Craig Jones) and has two daughters. But believe it or not, she somehow finds time to relax. When she is not working, Anne loves to go fly fishing. Perhaps this quote best sums up Anne Sheehan's life: "Daily ripples of excellence over time become a tsunami of success" – Robin Sharma.

Faculty News, Activities, Research & Lab Reports

Icy landscapes by Robert Anderson

Professors Irina Overeem, Suzanne Anderson, and Bob Anderson are engaged in a 3-year project on the north slope of Alaska. The team includes grad students Josie Arcuri and Cole Cochran, and postdoc Marisa Repasch. Their target is the carbon dynamics of the Canning River corridor. The Canning bounds the western margin of the Arctic National Wildlife Refuge (ANWR). Every component of the geomorphic system there involves the annual phase change of water from solid to liquid and back. There exist small glaciers in the Brooks Range headwaters, mere ghosts of their Last Glacial Maximum selves. The hillslopes are periglacial, sporting frost wedge polygons on the flats and occasional thermokarst slumps. The river freezes annually. Continuing spring flow in the winter generates broad icy regions on the flats called aufeis that persist well into the fall. And the entire system drains to the Beaufort Sea characterized by land-fast sea ice roughly nine months of the year. They, therefore, refer to this as the Icy Landscapes project.

The main question driving the research is how warming of the climate, which is occurring more rapidly in the Arctic than elsewhere, will affect the fate of carbon in the landscape. Much of the Arctic coastal plain across which the Canning flows, once it exits the Brooks Range, is dominated by frozen peat. As the active layer in the permafrost, the roughly half-meter thick part of the landscape that freezes and thaws on an annual basis deepens as the mean annual temperatures rise, it exposes carbon in this peat to the atmosphere and the hydrosphere from which it has been isolated for thousands of years. Does the old plant material simply decay to produce CO_2 and methane, or does it get ripped from the riverbanks to be exported to the ocean and get reburied without decay? Or something in between. The researchers are focused on the river corridor where the dynamics of the river rip away old banks, generate young surfaces on which new plant growth can fix carbon, and transports both particulates and dissolved carbon to the sea. It is a wild and pristine landscape. As



the river is ungauged, they have to rely on remotely sensed imagery, summer spot measurements of river discharge that they make with an ADCP and a one-man raft, and a winter installation of a look-down sonic river stage sensor. They are measuring the carbon stock on variously-aged vegetated surfaces on which they hope to establish age control using OSL.

In the summer 2022 they floated the length of the Canning in rafts, exploring the best sites for more concerted efforts in the following summers, collecting samples for C content, and documenting discharge. In Spring 2023, a smaller team including Josie Arcuri and Irina Overeem deployed instrumentation via snow machines to establish monitoring sites to capture the river breakup dynamics as the landscape warms toward the summer. This coming summer they will focus on 3 or 4 specific sites representing different land surface types and river behavior.

GRASCE Lab

by Leilani Arthurs

In the fall of 2022, the Geocognition Research for Advancing Science Education (GRASCE) Lab welcomed its newest member, Holly Fortener. Before joining us, Holly earned her Master's degree at Rice University. She is currently a PhD student conducting research on teaching-focused professional development programs at three US institutions of higher education and their potential to transform undergraduate STEM education.

In October 2022, Ph.D. students Collette Wilfong and Dr. Leilani Arthurs presented their research in Denver at the annual Geological Society of America (GSA) conference. Collette illustrated how the choice of theoretical frameworks in geoscience education research informs a study's design, results, and interpretations. Using a theoretical framework for workplace bullying and harassment, Leilani presented research about unwelcome student behaviors in undergraduate STEM classrooms and their impacts on STEM teaching and learning.

L - R: Holly Fortener, Cole Lombardi and Stephanie Tkacik.

Coincident with the GSA conference, Holly and other grad students led an outreach event at the Children's Museum of Denver that coincided with the annual GSA conference. On the outreach front, Collette also continued her position as an assistant in PI Carolyn Crow's Ad Astra program. Through these activities, Holly and Collette engaged many kids in the wonders of geoscience!

Carlton Lloyd

Collette Wilfong and Emerging Scholars Award.

December 2022 marked graduate student Carlton Lloyd's one-year anniversary working as a coordinator for Jackson School's GeoFORCE K-12 outreach program at the University of Texas at Austin. His thesis focuses on bridge programs that support students in transitioning from high school to college in STEM fields of study. So, his professional and graduate work are intimately connected. After more than a year of balancing full-time work and finishing up his graduate degree, Carlton graduated with his Master's in May 2023!

Awards: Collette received the Emerging Scholars Award from the Geoscience Education Research (GER) Division of the National Association of Geoscience Teachers (NAGT), a Graduate School Domestic Travel Grant, a GEOL Conference Travel Scholarship, and an NAGT Earth Educators' Rendezvous Stipend. Holly received a GEOL Conference Travel Scholarship and a Benson Fellowship Award. Leilani received an award from the National Science Foundation's program for Cultural Transformation in the Geoscience Community to advance departmental efforts to support existing and future graduate students from a wide range of backgrounds, build connections with local communities, and develop co-created plans for community-based research.

Colonization at the Extreme

by Brian Hynek

Undergraduate Sydney Ciechanowicz has been working with Brian Hynek in the microbiology lab to try and understand the details of how life colonizes a new aquatic environment at the top of an active volcano. The Poás volcano (Costa Rica) recently self-sterilized its entire crater through two continuous years of eruption. After it calmed down a new hot ultra-acidic lake formed, providing a natural laboratory to detail the colonization and ecological succession in a sterile freshwater setting. Brian has collected a three-year time series of environmental samples since the lake's inception and Sydney has extracted any DNA. While very few modern examples exist, these types of environments were likely commonplace on early Earth (and Mars) as life was trying to take hold against a backdrop of impacts and eruptions. Sydney's work is supported by an undergraduate research award (UROP) and an NSF award to Hynek.

Sydney preparing samples for DNA sequencing.

Ancient Mars on Modern Earth

by Brian Hynek

Brian Hynek, along with professors from U. Wisconsin and Indiana have recently completed two field seasons in northern Tanzania and are now planning the third. The target is super saline and alkaline Lake Natron and its ultramafic-hosted watersheds. The mineralogy and lake chemistry here are similar to ancient Lake Jezero on Mars, which is currently being investigated by the Perseverance rover. A source-to-sink mineralogy study is being completed at Natron to help interpret the deltaic sequence and watershed contributions at Mars. The work is supported by a three-year grant from NASA.

Professor McHenry (UW-Milwaukee) measuring the supersaturated lake Natron. Our Maasai guide Elias is learning how to do science while also keeping us safe from harmful animals in this remote setting.

It took 25 Tanzanians, 2 tractors, and 7 hours to free the land cruiser.

Craig Jones spent much of 2022 preparing for and helping to run a Geological Society of America Thompson Field Forum that was focused on evidence related to the uplift history of the Sierra Nevada. He was able to obtain funding from NSF that allowed 17 students and recent PhDs to attend for free. Thirteen professionals (including our own Becky Flowers) joined the early career people, Jones, and the three co-convenors on a week-long trip through the Sierra. Some of the highlights included examining paleocurrent indicators inconsistent with nearly any paleo drainage network previously proposed, seeing a portion of one of the central Sierra table mountain flows where its banks remain intact and topography on the flow top demands a subsequent tilt, and hiking to the top of another flow that has been the subject of fierce debate in the recent literature. A morning session on the last day tried to identify new research that might finally resolve whether the modern range has been sitting at these elevations for more than 35 million years or that it had been lower and since has risen up. The field guide from the meeting (clocking in at a mere 260 pages) will be updated and revised for publication by GSA, and a theme issue of Geosphere has been proposed with 15 papers already planned by various attendees.

Field Forum looking into Royal Gorge. CU alum Scott McCoy (now at UNR) is speaking.

Suzanne Anderson was elected to the leadership of the Earth and Planetary Surface Processes (EPSP) section of the American Geophysical Union (AGU). She will serve as President-Elect for two years, and then as President for two years. EPSP serves around 8000 AGU members who hold either primary or secondary affiliations with the section. As a member of section leadership, she also serves on the ~75-member AGU Council.
Suzanne reports that it's gratifying to be selected by her peers for this role and that she is looking forward to celebrating and supporting the work of members of the surface processes community.

Dr. Suzanne Anderson

@cu_boulder_geology
Check us out on Instagram
instagram.com/cu_boulder_geology/

Toby Halamka

Studying modern bacteria to help reconstruct temperatures of the past

by Casey Thater & Karen Chin (based on an interview with Toby Halamka and Sebastian Kopf)

It's around midnight in a small apartment with the light from a computer screen and a small lamp illuminating the plant-filled room of PhD student, Toby Halamka. The sporadic tapping of computer keys and squeaks from a dog toy can be heard. Tasked with finding a bacterial species that produces unusual lipid compounds, Toby works remotely, pouring over mass spectrometry data in a groggy state. Yet, although this started out as a typical night it would have a much more exciting ending.

Toby has been working her way through the biochemical data of the samples she extracted from about a dozen different species of lab-grown soil microbes. The goal is to find chemical signatures of cell membrane lipids (fat molecules) called branched glycerol dialkyl glycerol tetraethers (mercifully abbreviated to brGDGTs). These lipids are rarely found in bacterial cultures, so Toby does a double take as she stares at the data for Solibacter usitatus on the computer screen. The S. usitatus bacterium—later nicknamed Susi by the CU team—apparently makes a lot of these lipids. Thinking it must be an error she doubles- and triple-checks the data. To her excitement, the results don't change, and she quickly messages her advisor, Sebastian Kopf, with the exciting news. Toby and Sebastian want to determine whether the ratio of brGDGTs produced by living bacteria varies predictably with different growing temperatures. Toby's exciting discovery of Susi unlocks new dimensions in this research.

What are brGDGTs and why should we care? This challenging acronym refers to lipids from microbial cell membranes that are commonly found in soils. Found in nearly all modern terrestrial environments, these lipids can also be preserved in ancient sediments and serve as biomarker tools for estimating the temperatures of past terrestrial environments. The problem is that despite the ubiquity of these lipids in modern and past environments, no bacterial species had yet been shown to produce large quantities of brGDGTs in a lab environment. But Toby's late-night discovery demonstrated that lab-grown S. usitatus produce abundant brGdGts that can be studied to improve our understanding of these lipid biomarkers.

Scientists are still learning how brGDGT lipids function as paleothermometers. Clues about the process can be inferred from how different types of brGDGTs in a bacterial membrane can affect the membrane's properties. All cell membranes must be strong enough that they don't fall apart at different temperatures but still flexible enough to allow key molecules to pass through. Adding or subtracting "kinks" or "branches" to membrane lipid structures will alter how tightly the molecules can be packed together; more "kinks" means looser packing and more flexibility. Considering the differences between oil and butter at room temperature is an easy way to picture this. Oil lipids have many "kinks" in their structure so the molecules can't pack tightly and thus don't become rigid—hence the liquid state of oil at room temperature. The fats in butter have fewer "kinks" so the molecules can pack tightly, helping butter maintain a solid form at room temperature. So the hypothesis is that at higher temperatures, bacterial membranes will have more brGDGT lipids with fewer branches to retain their structure, whereas at lower temperatures they will have more brGDGTs with greater numbers of branches in order to remain flexible. This explanation is consistent with the observation that in colder temperatures, brGDGT lipids with more branches are found in modern soils.

The research team led by Toby Halamka and Sebastian Kopf found that the composition of brGDGTs in Susi's membranes changed with temperature in the same way that brGDGTs from modern and ancient sediments changed in response to temperature. This was big news! Although geologists have been using brGDGTs as paleothermometers they could never fully study the effects of temperature on the production of brGDGTs in cultured bacteria. Growing this bacterial species

was a frustratingly difficult and time-consuming process, and there were equipment failures and contaminations when other microbes snuck into long-term experiments. However, thanks to the care and watchful eye of professional research assistant Adam Younkin and some awesome 3D-printed equipment, the team was able to successfully grow Susi under different environmental conditions.

The first research findings from Susi were drawn from data collected here at CU and served as laboratory-based support for the use of brGDGTs as a paleothermometer. But it is also exciting that the results of this research were independently corroborated by a research team at the Southern University of Science and Technology (SUSTech) in Shenzhen, China who coincidentally studied Susi at the same time. They too concluded that Susi's brGDGT response to changing temperature follows the same temperature trends of ancient and modern environmental brGDGT biomarkers. The story of cooperation between the CU and SUSTech teams is refreshing because science is often highly competitive and sometimes adversarial. These cooperative research teams offer an excellent example of how collegial science should be conducted.

The CU team continues to study Susi by exploring the possible effects of different pH and oxygen levels on brGDGT production and the potential for using brGDGTs to identify low-oxygen environments in the past. Additionally, Toby was awarded a grant from the European Association of Organic Geochemistry to investigate the intact polar lipids in Susi at the Hinrichs lab at the Universität Bremen, Germany. All of these outcomes and exciting new directions are thanks to the late night when Toby met Susi.

Toby expects to finish her doctorate in Geological Sciences in December and Sebastian Kopf will continue his studies on a wide range of biogeochemical and geobiological questions. Of course, he is hoping to continue working on these enigmatic brGDGTs to determine why they are produced and the mechanisms behind their biosynthesis. Their paper "Production of diverse brGDGTs by Acidobacterium Solibacter usitatus in response to temperature, pH, and O2 provides a culturing perspective on brGDGT proxies and biosynthesis" was published in Geobiology in September 2022.

Organic Geochemistry Group

by Julio Sepúlveda

The Organic Geochemistry Group saw the departure of lab manager Dr. Nadia Dildar (now at USC, CA), PRA Katie Eaman (now a grad student at the University at Buffalo, NY), graduate student Dr. Lina Pérez-Angel (now a postdoctoral fellow at Brown University), postdoc Dr. Nicolò Ardenghi, and undergraduate assistant Muhammad Haikal Ezhar Abu Bakar. We wish them all the best in their future endeavors. We also welcomed Drs. Maria Luisa Sanchez-Montes (summer 2022) and Edgart Flores (spring 2023) as new postdoctoral Researchers. Edgart successfully defended his PhD thesis in Oceanography at the University of Concepción, Chile in spring 2023 under the co-supervision of collaborators Prof. Osvaldo Ulloa and Julio. Also, Dr. Jon Raberg, a recent grad student in our group, transitioned to a postdoctoral position (co-mentored by G. Miller and A. Geirsdóttir) in the spring of 2022. Other members of our group include graduate students Harry Allbrook and Robert Kelleher, postdoc Dr. David Harning (co-mentored by G. Miller and A. Geirsdóttir), and PRA Brooke Holmans. In summer 2022, we also welcomed two minority undergraduate summer students; Amanda Urist, a sophomore at Penn State University through CU's SMART Program (mentored by Jon and David), and Kira Biener, a junior at the University of Michigan through the UNAVCO-RESESS Program (mentored by Robert). Our group continued to explore the impacts of climate change in terrestrial and marine ecosystems, both today and in the past. With the continuing support from NSF, three of our six ongoing awards received supplements to continue our work in the tropical Andes, Baffin Island, and Iceland. Our team completed successful field campaigns in Baffin Island and central and southern Chile. Graduate student Harry Allbrook and professor Julio participated in the German-Chilean Research Cruise SO296/2 onboard the RV SONNE, which explored the impacts of oxygen-deficient

R/V Sonne during Cruise SO296/2 in the fjord system of southern Patagonia (spring 2023)

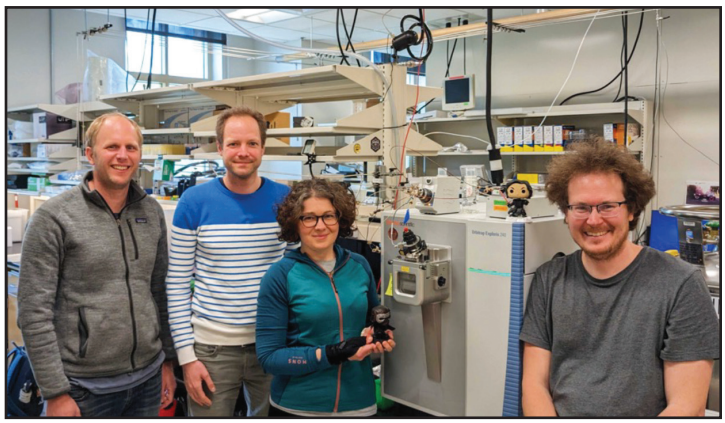
Water column collection with rosette and CTD during Cruise SO296/2 (spring 2023).

Water sampling by Harry and Julio during Cruise SO296/2 (spring 2023).

waters on marine microbial ecosystems off the coast of central Chile and in southern Patagonia, as well as glacial melting in Patagonian ecosystems since the last deglaciation. Julio became a fellow of the RIO Faculty Fellows Program cohort 2022 and he gave a Ted-like talk titled “The secret stories of marine microbes” as part of CU Boulder’s annual Research & Innovation Week. He was promoted to Associate Professor with Tenure in 2022 and enjoyed a year-long sabbatical that included three months in Chile performing fieldwork in Patagonia and collaborations with colleagues at the University of Concepción, Chile. Lastly, our group is excited to welcome Dr. Lennart van Maldegem as our new lab manager in the summer of 2023. We look forward to entering a new phase of our group with his support!

In the Organic Geochemistry Lab, a new instrument was installed in December 2022 – a soft ionization Orbitrap isotope ratio mass spectrometer. The instrument is a multi-year loan from Thermo Fisher and is used to enable novel and precise quantification of “isotopocules” (isotopically substituted molecules) that have not been analytically accessible so far. This now provides direct access to isotopes in intact polar solutes such as amino acids and oxyanions, without having to convert analytes to gases. The project is led by Dr. Caj Neubauer (INSTAAR) and Prof. Sebastian Kopf. Dr. Kristýna Kantnerová joined in May 2022 with a postdoctoral fellowship from the Swiss National Science Foundation, working on techniques for oxyanions from environmental waters. Current research topics we pursue using this approach relate to environmental pollution, microbial metabolism, climate records in ice cores, and the paleodiet of early humans.

Drs. Brett Davidheiser (Thermo), Caj Neubauer, Kristýna Kantnerová, and Seb Kopf in front of the new Thermo Scientific Orbitrap Exploris 240 (spring 2023).



Paul Weimer

Paul finished his term as President of the American Geosciences Institute last October at the GSA Convention in Denver. In celebration of AGI's Diamond (75th) Anniversary, he co-convened a special one-day session on the future of geosciences. The speaker list included current and past luminaries in the field (see photo). He serves as Past-President of AGI and the acting chair of the Geoscience Development Roundtable, the successor group to the AGI Foundation.

In February, he gave a keynote talk at the centennial celebration of his undergrad department, "The Sedimentary Geosciences and Pomona College: From Southern California and Beyond."

In April, his class visited Antero Resources for an afternoon (photo on the bottom of this page).

Paul Weimer will retire from the Department of Geological Sciences in December of 2023.

Paul with keynote speaker Senator Hickenlooper, erstwhile geologist/brewer-restaurateur/Mayor/Governor.

In association with Paul's retirement at the end of the calendar year, the State of Colorado has agreed to issue a one-time modification of their newest automobile license plate (Thanks, Steve!)

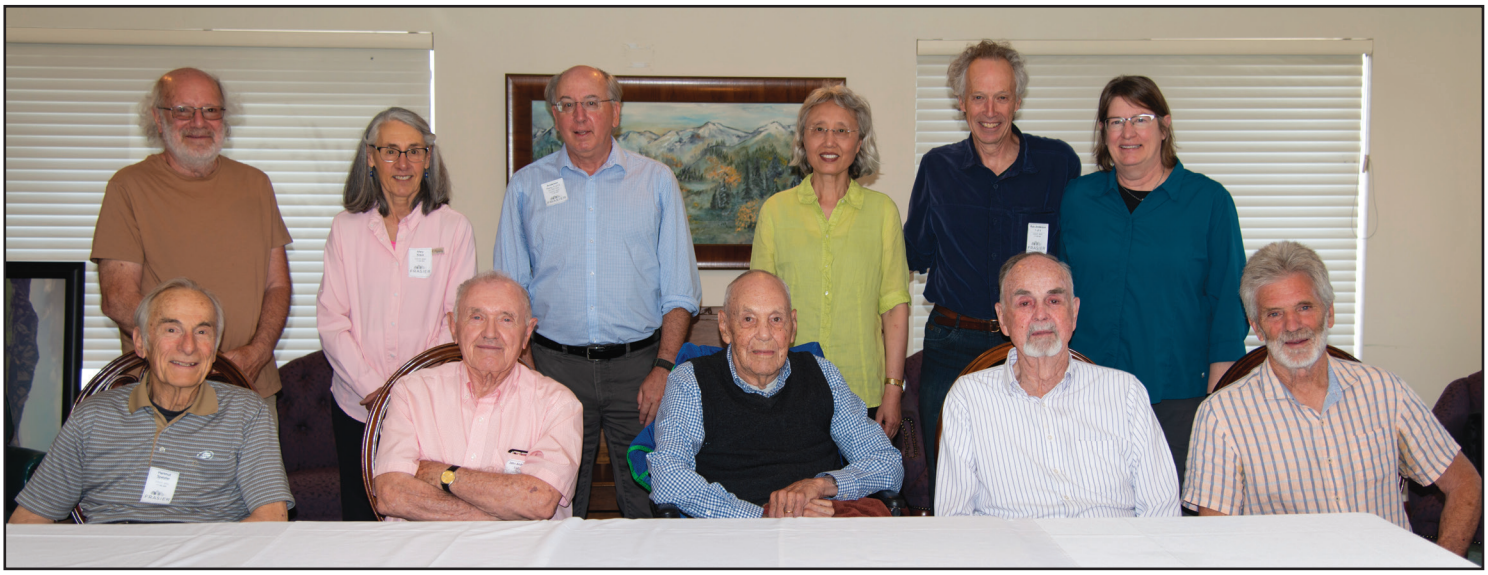
February 23, 2023 - A spectacular day looking towards the flatirons from the Benson Earth Sciences 3rd-floor balcony. photo credit: Bob Anderson

CU visits Antero Resources, Paul Rady, Maria Henry, and Ryan O'Hara (CU GEOL 3540 class).

Junior faculty celebrating Katie Snell's tenure

May 2023 gathering of all junior faculty at a celebration of Katie Snell's tenure, joined by Alexis and Boz. From left to right: Lizzy Trower, Katie Snell, Carolyn Crow, Shaily Rahman, Alexis Templeton (not junior), Boz Wing (also not junior), Carl Simpson, Brad Markle, Alisha Clark, and Seb Kopf. This is the future of our department.

Chuck Stern	**Mary Kraus**	**Lang Farmer**	**Shemin Ge**	**Bob Anderson**	**Anne Sheehan**
1998-2003	2003-2009	2009-2015	2015-2019	2019-2023	2023-



Hartmut Spetzler	**John Andrews**	**Bill Bradley**	**Don Runnells**	**Giff Miller**
1984-1987	1987-1990	1968-1972	1990-1992	1993-1998

Past, present, and future chairs of the Department of Geological Sciences met at Frasier Meadows on June 7th, 2023 to mingle, have lunch and chat about the department. With the exception of Bill Bradley, who deserves to be front and center, they are standing in chronological order, left to right, and front to back. It is remarkable that the string from 1984 onward is intact, and equally remarkable that we reach back to Bill Bradley, now 98.

A coffee hour outside the Benson Earth Sciences Building on a nice Wednesday in February 2023. Coffee hour is now a weekly affair at which grads, undergrads, researchers, staff, and faculty can mingle while providing both fluid and solid refreshments.

Past and present chairs of the department assembled at the retirement party for David Budd and Giff Miller. Assembled in order of their terms as chair, left to right: Hartmut Spetzler, Giff Miller, Chuck Stern (pictured), Mary Kraus, Lang Farmer, Shemin Ge, and Bob Anderson

Geology Picnic @ North Boulder Park

Bob Anderson receives a Chair gift from the department at the 2023 departmental picnic May 4th at North Boulder Park.
photo credit: Alexis Templeton

Photos on this page were submitted by
Anne Sheehan & Alexis Templeton

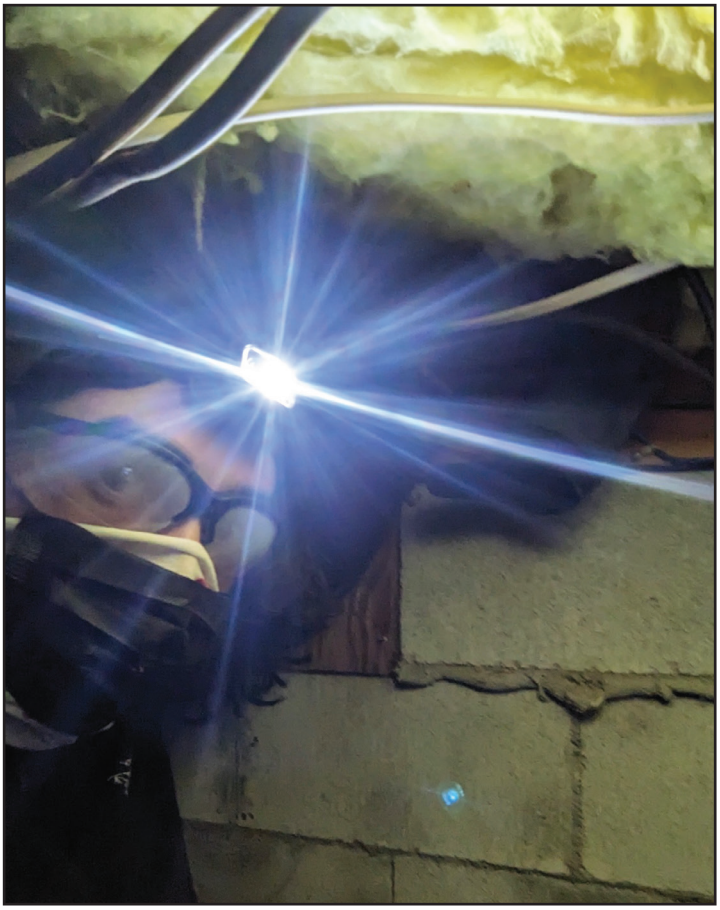
Geological Sciences Graduation Ceremony Spring 2023

Photos on this page were submitted by Anne Sheehan & Alexis Templeton

Fall 2022 Geological Sciences Graduation Ceremony.

Using Telecom Optical Fiber to Sense Tectonic Movement along the Cascadia Subduction Zone

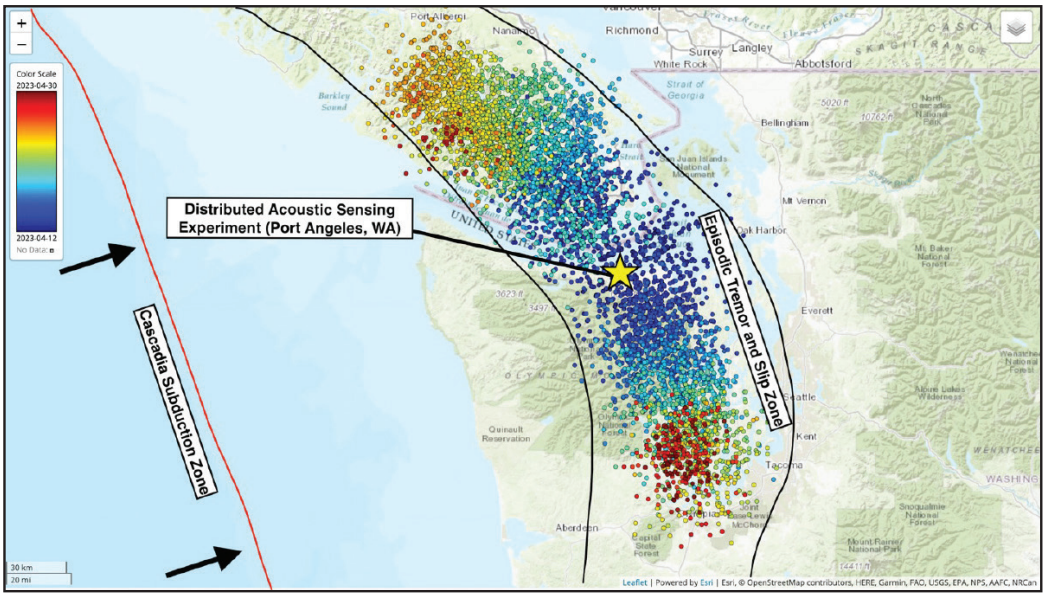
by Matt Mendoza



Postdoc Matt Mendoza in crawl space, cautiously setting up fiber at the building site powering the DAS array.

In April 2023, CU GEOL/CIRES Postdoc Matt Mendoza and Prof. Anne Sheehan, in collaboration with researchers at the Colorado School of Mines and University of Washington, deployed a 4.5 km long Distributed Acoustic Sensing (DAS) array in Port Angeles, WA, to capture a ~2-week tectonic event along the Cascadia Subduction Zone called Episodic Tremor and Slip (ETS). DAS is a new technique that works by converting “dark” (unlit) telecommunication fiber into a dense (m-level), high-resolution sensing element. It uses an optoelectronic device (known as an interrogator unit) that fires laser light thousands of times a second down the length of the fiber, while simultaneously measuring changes in the backscattered light when the fiber is perturbed (strained) by seismic waves traveling through the Earth. In other words, this technique is a way to turn telecommunication fibers into the equivalent of strings of thousands of geophones – recording devices that are highly sensitive to ground motions, but more challenging to densely deploy and operate long-term.

The Cascadia Subduction Zone is a 1,000 km long tsunamigenic megathrust fault that stretches from Northern California to Vancouver Island, Canada. The shallow segment (<30 km) of the fault is frictionally locked and capable of hosting an M8 or greater earthquake, with the last known one to have occurred over 300 years ago. Down-dip (>30 km) of this locked segment, however, the fault slips slowly a few cm roughly every year as an ETS event. The seismic component, tremor, has been closely monitored since the early 2000’s using conventional seismometers and geophones, to understand how ETS events are transferring stress up-dip and pushing the locked segment of the fault closer to failure. The CU team will be recording DAS data continuously for the next 12 months to detect and characterize regional seismicity and local subsurface processes. Should the outcomes of this pilot experiment prove fruitful, it may help set the precedent for more permanent and larger-scale fiber-based seismic arrays for seismic monitoring of the Pacific Northwest, and beyond. More information about this recent deployment can be found at the bottom of the following blog: https://pnsn.org/tremor/tremor-log/ets-event-of-winter-20222023



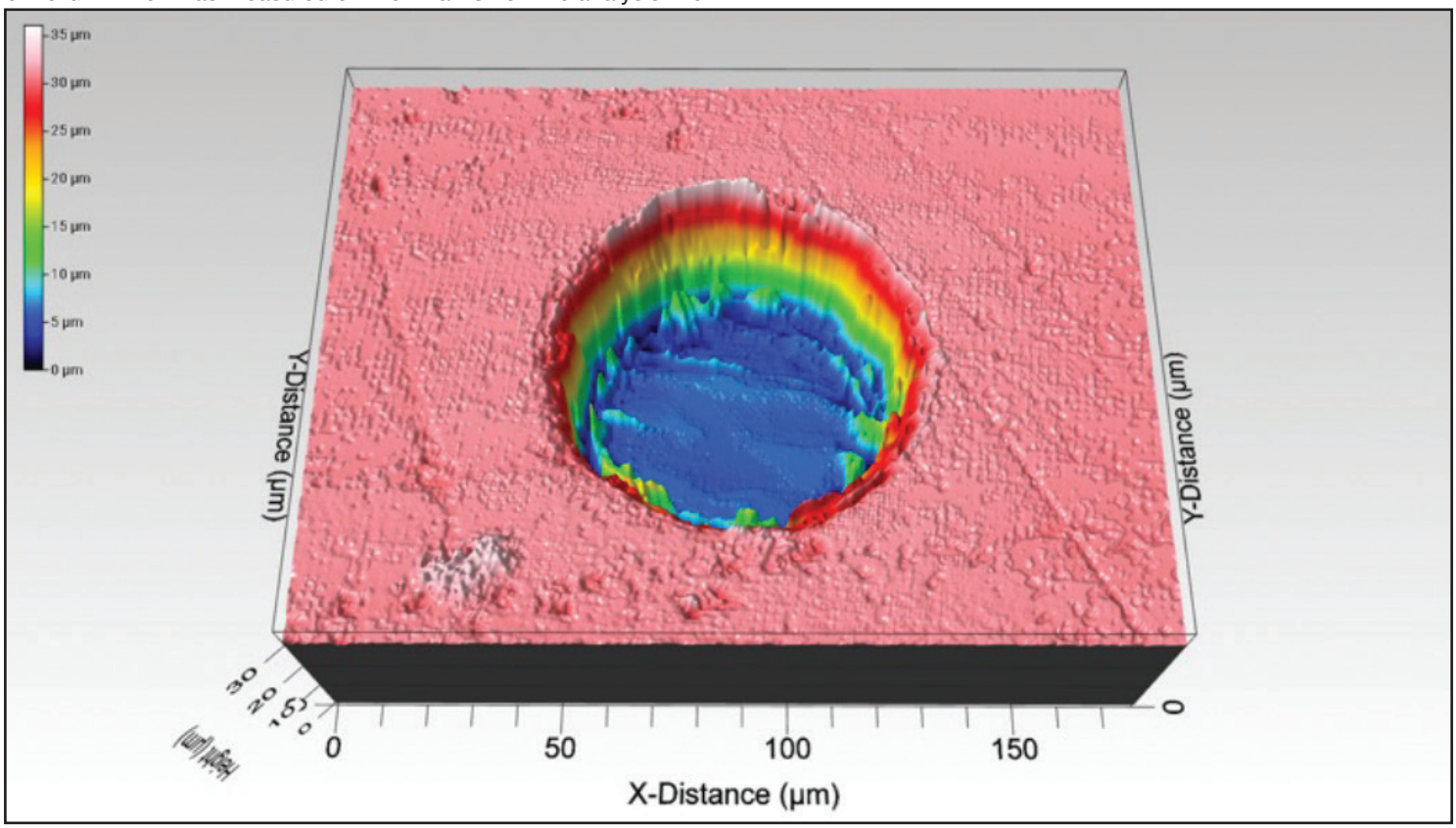
Northwestern Washington tremor map color-coded in time from 4/12/23 (start of the experiment) to 4/30/23 – data from the Pacific Northwest Seismic Network. Schematic lines are superimposed to approximate the location of major tectonic zones. The site of the DAS experiment is shown at the yellow star.

CU TRaIL by Jim Metcalf and Becky Flowers

The CU TRaIL (Thermochronology Research and Instrumentation Lab) had another busy year of laboratory improvements and innovative science. After a few years of work, we are now moving out of the installing and building new analytical equipment phase and into a more regular and routine operational phase for the excimer laser, new helium analysis line, and optical profiler. These new machines have greatly expanded the analytical capabilities of the lab and are opening up new and exciting science and scientific collaborations for the Flowers research group.

This year we welcomed Dr. Liam Courtney-Davies, a geologist with expertise in geochronology and laser ablation, as a new postdoc in the lab. Liam has finished setting up routine in situ LA-ICP-MS measurements and data analysis of a variety of materials including zircon and hematite. The TRaIL also welcomed new Ph.D. student Connor-Antonio Diaz to CU. Connor is working on the thermochronology of lunar samples, specifically using phosphates returned on the Apollo missions to better understand the impact history of the lunar surface. Connor has had a busy year characterizing these precious samples and preparing them for (U-Th)/He analysis. Ph.D. student Barra Peak has continued her work on the thermal history of the Great Unconformity, focusing recently on exposures from southern Canada. While Ph.D. student Spencer Zeigler continues her examination of kimberlite thermochronology, Spencer also published a study they began as an undergraduate in the TRaIL that used nano-computed tomography to better understand the uncertainties associated with data reduction in (U-Th)/He chronology. Recent CU alum Sabrina Kainz has also been working in the TRaIL this year as a laboratory assistant, helping with laser-ablation analyses and establishing protocols for mounting geologic samples in materials that are appropriate for ultra-high vacuum lines. Lab Manager Dr. Jim Metcalf continues his work on the new, custom helium analysis line, which he has now both calibrated and automated. Jim and Professor Rebecca Flowers recently used the new helium line and the new excimer laser to make the lab's first in situ helium measurements. Dr. Flowers continues to mentor the above student projects and has coauthored a suite of papers out of the TRaIL group over the last year. She also is the lead PI of the AGeS3 program, a $2.5M initiative recently funded for 5 years by the NSF Frontier Research in Earth Sciences program. AGeS is aimed at expanding access to and advancing the field of geochronology.

75 micron wide laser ablation hole in Durango apatite. This spot yielded 3.8 fmol of helium which was measured on the TRaIL's new He analysis line.



In the Field

Planetary Field Geology in Death Valley and the Mojave Desert

by Brian Hynek

Over Spring Break, a dozen graduate students embarked on a field course to study planetary analog environments in Death Valley and the Mojave Desert. This annual course brings together geologists, astronomers, aerospace engineers, and microbiologists to understand key processes that operated on other planets throughout time. The topics ranged from various styles of volcanism, tectonics, extremophile life living within salt crusts, and fluvial, pluvial, and eolian processes. We also spent time outside the parks hunting trilobites and mantle xenoliths, which the students got to bring home.

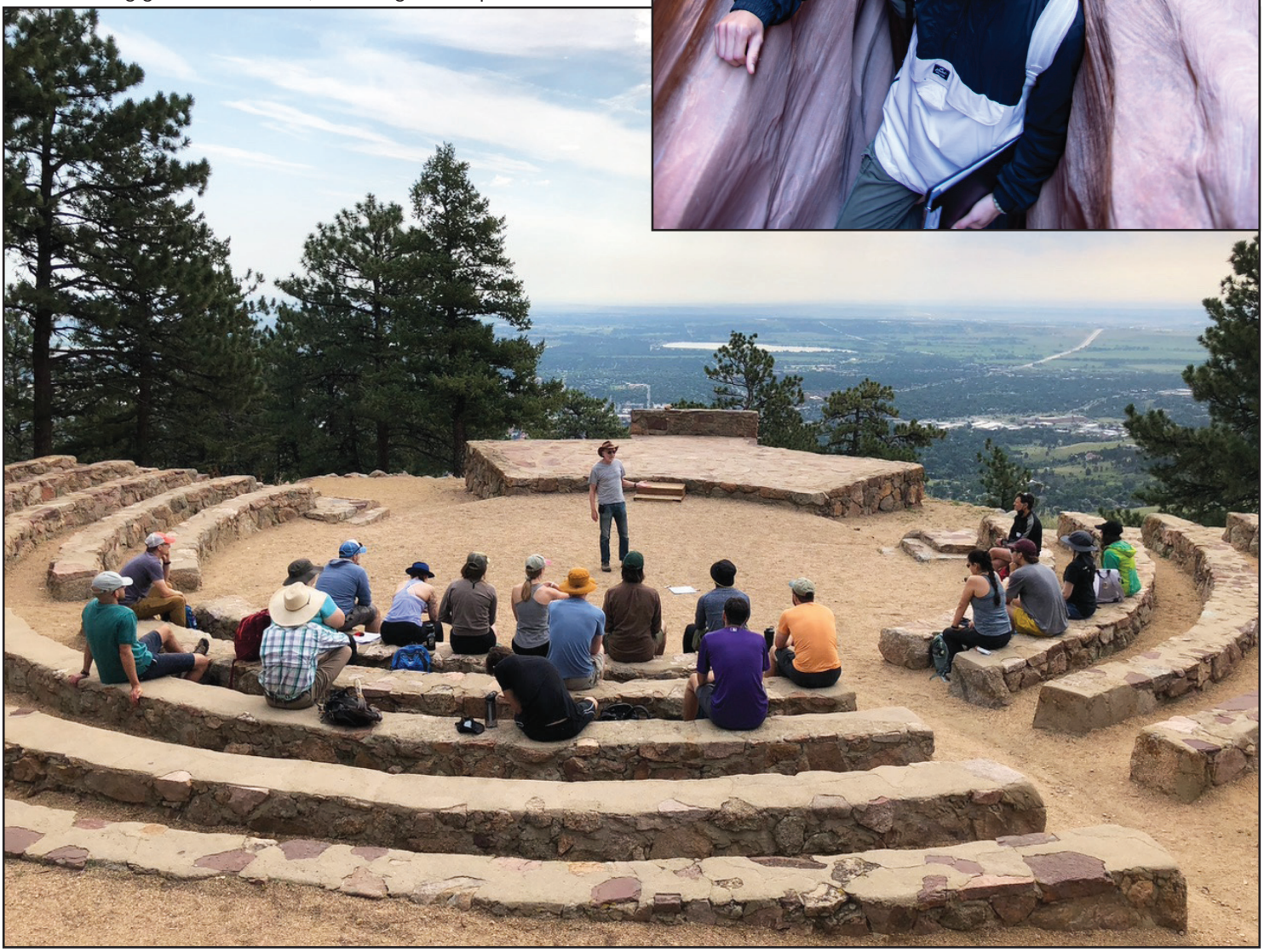
Students exploring a lava tube in the Cima Volcanic Field. photo credit: Brian Hynek

Your generous support helps to fund many of our graduate and undergraduate field trips.
Thank you!

Field geophysics class in Fall 2022. photo credit: Craig Jones

Spring 2023 Geomorphology class in Little Wildhorse slot canyon, on our 4-day class fieldtrip to the Utah desert.

Dr. Craig Jones holding forth on the Intro Fieldtrip for the class of 2022 incoming graduate students, from Flagstaff amphitheater.



GEOL 4717/5717 - Western U.S. Tectonics Returns to the Field

by Craig Jones

GEOL4717/5717 class, from the left, TA Lindsay Harrison, Judice Gao, Desiree Dsouza, Lauren Dickinson, Isaac Leb, John Parish, Jadon Hoffman, Vanessa Gabel and Qianxi Linghu.

After a lapse of six years owing to a multitude of complications, the spring break western U.S. tectonics seminar trip (GEOL 4717/5717) finally returned to the field. Unfortunately, the weather wasn't as enthusing as the students; the first campground was unreachable owing to a muddy road, leading to camping on Mancos Shale which was locally still in mud form. After a snow squall overnight, the trip proceeded towards warmer climes, though not before getting blasted by another sharp snow squall in Monticello, UT. A hike at Canyon deChelly had to be skipped as the trail was closed by the park. Perseverance paid off later as the class got to hike around Petrified Forest and learn about the relationship of those rocks to the development of a convergent margin on the west side of North America. After a last cramped and cool night at a small campsite near the Salt River Canyon, the trip continued only to discover that the BLM roadmap near the EagleTail Wilderness wasn't as up-to-date as was hoped. This did permit a scenic campsite far from civilization (and the discovery of lots of actinolites nearby), but this also provided a bit more adversity as they had a flat tire. Still, they visited the enigmatic pieces of peridotite (now largely serpentinite) in an exposure of the Orocopia Schist before traveling back on better roads to get the tire fixed. this then allowed exploration into the Buckskin Mountains and the large detachment fault seen there near the old town site of Swansea. On the way to our hotel in Laughlin, though, some big potholes caught one tire, which went flat. After a fruitless discussion with the rental car helpline, a late-night repair was completed by Needles; the noble occupants of that vehicle were greeted at their late arrival in Laughlin. With food supplies restored, the trip headed for the Kingston Range, where pieces of magnetite that had fallen off of ore trucks delighted class members. From there, a relatively early stop was made at Tecopa Hot Springs, and while the winds were annoying, the hot waters soothed some students. The next day was a whirlwind tour of Death Valley, where the hike past the Natural

Desiree at Strike Valley overlook talking about monoclines

Vanessa (right) discussing the Rawhide-Buckskin detachment

Bridge allowed examination of the turtleback-style detachment fault in the Black Mountains. The weather decayed as the group started to head back east, with winds picking up there was a visit to the Las Vegas Valley Shear Zone just before it started to rain. Fortunately in the time taken to get to the evening's campsite, the showers passed through and a pleasant evening was had by all. The next day saw a return to higher elevations, and here the rain showers and wet late winter had left the roads to the Toroweep area of the Grand Canyon impassable. So a detour to a vista point on the west flank of the Kaibab Plateau was made to hopefully allow presenters to point out their geologic features the distance, but a return of snow eliminated the visibility (at least there were the signs identifying what you usually could see from the viewpoint). With the weather again decaying, Dr. Jones decided to seek refuge for the class in a motel in Kanab, which also allowed for a pizza dinner for nearly all. Having been deprived of the Grand Canyon, an effort the next day got the trip to Strike Valley Overlook in Capital Reef National Park to discuss monoclines, even though the trip had to be an out-and-back due to roads farther down probably being impassable. A final night at the small Deer Creek BLM campsite featured some private landowners driving in and out past the campsite to their Bedrock Homestead Air BnB farther up the canyon. With that, the weather gods decided the class had been punished enough and so had a smooth and uneventful drive back to Boulder.

Most of the class ran after a river otter that they saw at lunch on the San Miguel River, and they did add a detour into Bryce Canyon and then Escalante Petrified Forest to make up for not getting to the Grand Canyon this outing.

Lindsay stands next to a big cactus, Eagletail Mtn Wilderness (Cemetery Ridge).

Colorado Stories – A new geology-based Living and Learning Community at CU

by Lon Abbott and Bob Anderson

CU has long provided theme-based residential living experiences for first-year students via its Residential Academic Programs (RAPs). Research on the academic benefits produced by student engagement in such communities of like-minded people is so convincing that the university has prioritized expanding its offerings in that realm to ensure that every new CU student can participate in one. To that end, CU recently put out a call for the development of new Living and Learning Communities (LLCs), which help students build social connections as they live with other students who share similar interests. The geology department answered that call; this fall we are launching the Colorado Stories LLC, which explores how Colorado's geology has shaped the state's human history. All twenty-eight first-year students who signed up to participate in Colorado Stories will enroll in GEOL1040 – Geology of Colorado and participate in organized activities and co-curricular learning opportunities.

The LLC is being organized by Lon Abbott and Bob Anderson and they also teach the Geology of Colorado class. The class traces the state's geologic history, from the formation of its first continental crust about 1700 million years ago to the rise of at least three different mountain ranges to the growth of mighty glaciers in the current mountains during the Pleistocene. Lectures and activities will help students paint mental images of the state's ever-changing landscape, from vast fields of sand dunes 285 million years ago to a shallow sea 80 million years ago to hosting one of the world's first rain forests 64 million years ago.

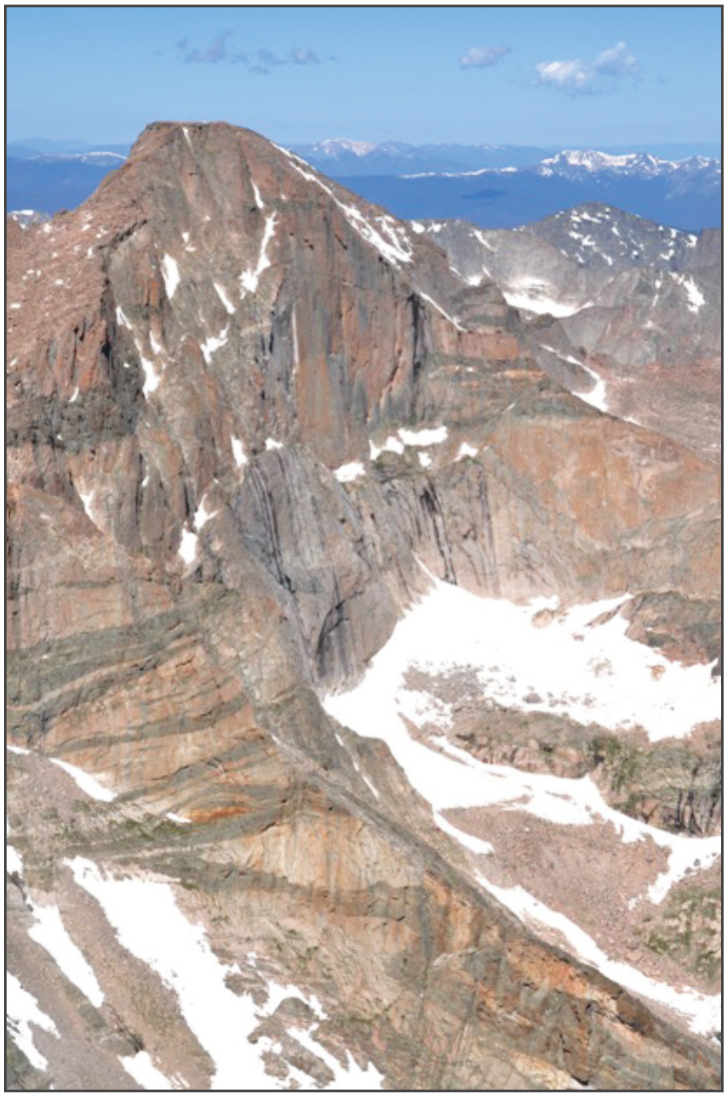
Colorado Stories students will augment their classroom learning with field trips to places where we can observe and interpret the evidence that reveals those past events and witness the grandeur of the modern landscapes wrought by the most recent ones. We'll learn how science is conducted through visits to cutting-edge scientific laboratories run by departmental faculty and other Front Range earth scientists. Other trips, to places like the History Colorado Center, will explore the state's human history, where we will make connections between that history and its geologic underpinnings. The link between human and geologic history in Colorado is often explicit, such as the gold-producing geologic processes that triggered the Pikes Peak gold rush in 1859. Others are more subtle, like the geologic reasons that Colorado Springs became home to the North American Aerospace Defense Command (NORAD) in 1966 and the U.S. Olympic and Paralympic Committee in 1978.

We won't end our explorations of the link between geology and human concerns at the present day; we'll also examine how Colorado's climate, geography, and resource base are likely to shape the lives of future Coloradans.

Here are two vignettes that illustrate how we intend to help Colorado Stories students gain a deeper appreciation for Colorado's geologic history and enable them to connect that history to their own lives and passions.

Longs Peak, at 14,259 ft, pokes well above much of the landscape in Rocky Mountain National Park just to the northwest of Boulder, here seen in an aerial photo looking directly west. It is named for the explorer Major Stephen Long who led an expedition to the

photo credit: Robert Anderson



west in 1820. The tall, steep rock cliff leading to the sunlit summit – called The Diamond – is the site of some of the state's most famous rock-climbing challenges. It sits at the head of a long valley that only 18 thousand years ago hosted a big glacier whose edges are recorded by the forested moraine ridges that bound the valley. Glacial ice has repeatedly carved many of the valleys in Colorado's mountain ranges over the last couple million years, leaving lumpy bedrock valley floors, tall headwalls, and morainal ridges as the clues we have learned to read.

photo credit: Robert Anderson

photo credit:
Lon Abbott and Terri Cook

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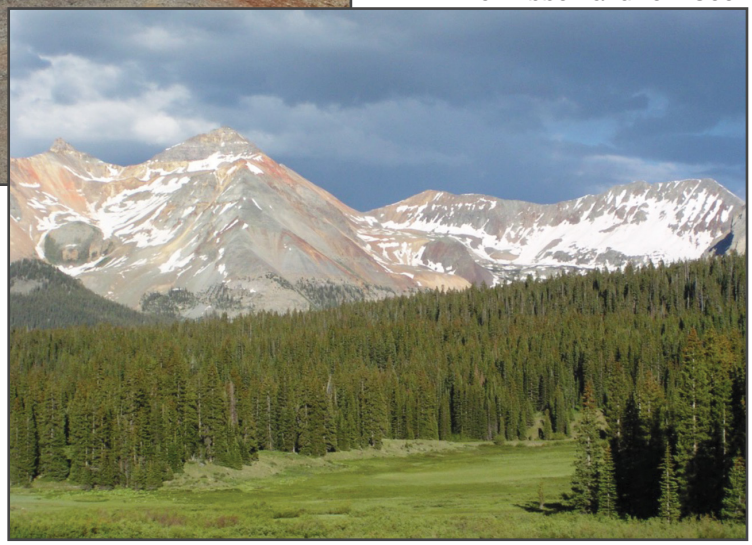
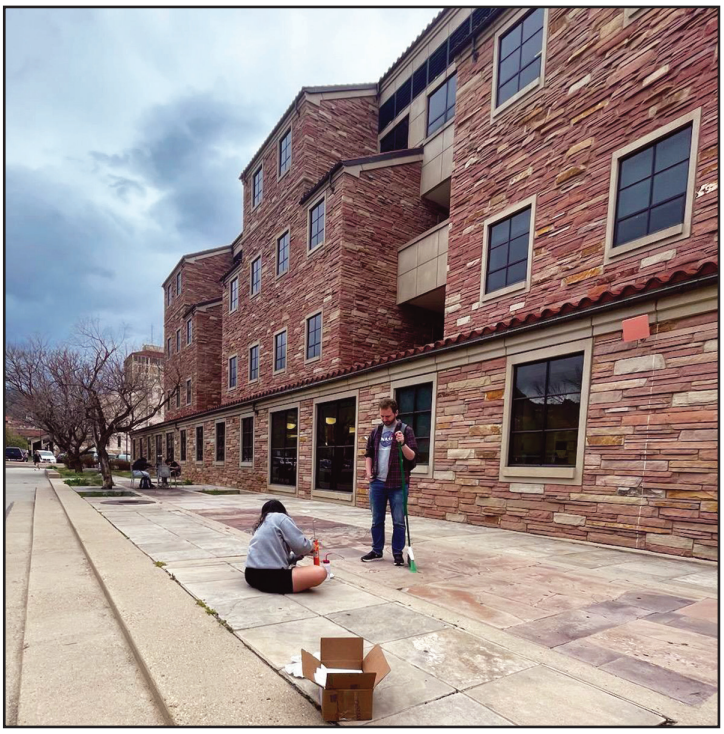
Lon Abbott and Terri Cook



Southwestern Colorado's **San Juan Mountain range** is made up of the eroded remnants of dozens of volcanoes that were erupting between 35-25 million years ago. This includes the world's largest volcanic caldera, whose violent eruption 28 million years ago spewed enough volcanic ash to cover the entire state of California to a depth of almost 40 feet (12 m)! Ten of Colorado's 54 famous "Fourteeners" – mountain peaks over 14,000 feet (4268 m) elevation have been carved by glacial erosion from these ancient volcanoes.

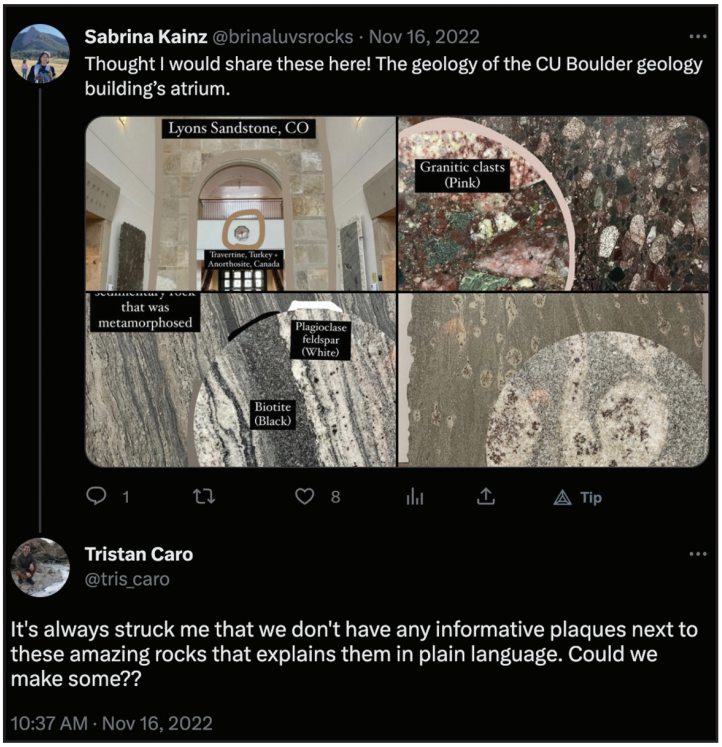
Benson Earth Rocks and Fossils

by Sabrina Kainz and Tristan Caro



Tristan and Sabrina installing descriptions to the Arrow of Time outside of the Benson Earth Sciences building.

What started as a Twitter thread about the rock slabs around the Benson Atrium turned into a 6-month long project by Tristan Caro and Sabrina Kainz to create lasting descriptions of the artwork around the building.



Built in 1997, the Benson Earth Sciences Building has an impressive collection of rocks and fossils from all over the world, yet have remained without context for decades. Tristan and Sabrina made it their goal to create plaques for the specimens that explained their geologic and human history in plain language. Although many of those reading may be well-versed in geology jargon, much of Benson's foot traffic is students taking introductory classes. To provide an interesting story of the formation and to give a peek into geologic time, Tristan and Sabrina set out to find out
how these rocks got to Benson (all with the help of many people who helped create, install, and donate these pieces). The plaques were fabricated by Tristan and Sabrina. They are composed of an anodized aluminum surface that was laser-etched at the Integrated Teaching and Learning Laboratory in the engineering center.

Much effort was put into the detective work required to track down information about these pieces. Invaluable information on the collections was provided by Dana Hauschulz, Karl Mueller, Giff Miller, Roy Young, Chance Anderson, Bob Anderson, and Lon Abbott.

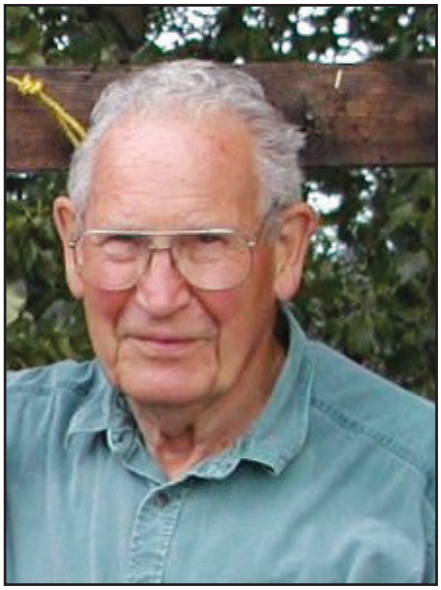
Artist and engineer Dana Hauschulz standing next to his gneiss that he named 'Bob'. photo credit: Sabrina Kainz

Attention Alumni

You can help us do a better job of keeping up with you, your whereabouts, and your career or family news. We all enjoy reading about classmates and not-so-close-mates who survived Boulder in whatever era! So send us some news or some recollections—we promise to use them.

Email your Alumni News to: GeoAlum@Colorado.EDU

Lucas J. Kimes Fellowship Created



In the Spring of 2023, the Trower family created the Department of Geological Sciences' first postdoctoral fellowship. The University of Colorado Boulder Office of Advancement and the Department would like to thank the Trower family for putting together this biographical information for Lucas J. Kimes

Lucas J. Kimes was born in Van Buren, Arkansas in 1923. Confronted with the Dust Bowl, his family had to sell their Arkansas farm in 1929 and travel to California. Lucas grew up in Porterville, and after graduating from high school in 1940, studied at Porterville Junior College. He had his sights set on becoming an aeronautical engineer, and in July 1943, he enrolled at the University of Colorado, Boulder, a participant in the V-12 Navy College Training Program. At CU he studied engineering and joined both the Pi Tau Sigma and Tau Beta Pi honor societies. In March 1945, Lucas had to leave CU for Navy Midshipmen training at Cornell, then served in the Pacific Theatre with the United States Naval Reserve until 1946. He used his CU education to get a job at Boeing in Seattle, and over his 41-year career, there rose to the position of Chief Engineer. After his retirement in 1987, Lucas pursued his passion for geology and fossil hunting with his wife. He panned for gold in Alaska, hunted for gemstones and quartz crystals all over the West, and looked for fossils on the Oregon coast. They brought the treasures they found home to Seattle and shared them with family and friends. This award fund is an expression of gratitude to CU for its important part in Lucas' career path and success and a way of encouraging geology scholars to continue in research and study.

Lucas Kimes panning fo gold in Alaska circa 2002

Benson Fellows Appreciation Dinner

Hosted by the advancement office, the graduate students supported on Benson Fellowships this year, along with several of the department's faculty attended a dinner held at the Denver Country Club Friday evening May 5th. Also attending were Lang Farmer as interim dean of the Natural Sciences Division of the College of Arts and Sciences, Dean of the College Glen Krutz, Chancellor Phil DiStefano, and CU President Todd Saliman. The event featured the roll-out of a video showcasing the Benson Fellows and their research. The focus was on the philanthropy of the Bensons, and the appreciation of the department, college, and CU for all they have done.

Bruce and Marcy Benson and the Benson Fellows. In the back row, left to right: Kara Bajdas (graduate program coordinator), Abby Eckland, Eva Jorn, Jordy Herbert, Harp Batther, Vanessa Gabel, and Michael Frothingham.

Undergraduate Student Awards

Geology Excellence Fund & Gustafson Endowed Scholarship
Misha Toor

Kolber Scholarship
Andreia Merten
Ryan Flat

Stephen Evans Scholarship
Haikal Abu Bakar

T. Keith Marks Scholarship
Leo Zook

Philip G Worchester Scholarship
Isla Griston

Graduate Student Awards & Fellowships

Benson Fellowship
Haley Brumberger
Holly Fortner
Jim Gutoski
Amanda Steckel
Ethan Pierce

T. Keith Marks Scholarship
Jim Gutoski

Longley, Washlstron & Warner, and Encana Graduate Student Award
Ella Hara

W. Thompson Graduate Research
Liza Wernicke

Bruce Curtis Scholarship
Earl White Jr.

Stephen Evans Scholarship
Harp Batther

Stanton Scholarship
Jen Davis

GEOLOGY

Graduate Student First-authored Publications

Bernard Archer, Döbelin, N., Archer, R., & Tu, V. (2022). A free and open-source solution for Rietveld refinement of XRD data from the CheMin instrument onboard the Mars rover Curiosity. Planetary and Space Science, 224(105596). https://doi.org/10.1016/j.pss.2022.105596.

Zeigler, S. D., Metcalf, J. R., and Flowers, R. M.: A practical method for assigning uncertainty and improving the accuracy of alpha-ejection corrections and eU concentrations in apatite (U–Th)/He chronology, Geochronology, 5, 197–228, https://doi.org/10.5194/gchron-5-197-2023, 2023.

Graduate Student Research, Outreach, and Recognitions

Tristan Caro - In early 2022, the department awarded me the use of research funds to pursue a specific research project with my advisor, Alexis Templeton on whether Raman spectroscopy can quantitatively measure hydrogen isotopes in microorganisms. We are in the process of writing up our results for submission to a peer-reviewed journal. This research, supported by the geological sciences department, will likely represent a chapter of my doctoral thesis. We are grateful for the department's support and are excited to have results to share with you.

Claudia Corona - Claudia used her Departmental Research Award to support her research work and writing of her most recent first-author publication in the Journal of Hydrology - Water Table Response to Extreme Precipitation Events. Extreme precipitation events (EPEs) are expected to occur more frequently on a global scale, possibly increasing the risk of major flooding and affecting the subsurface process of infiltration to recharge groundwater. An example of one such EPE occurred along the Front Range in 2013. This past year, Claudia used computer models to simulate a particular size EPE event, namely a 0.1 annual exceedance probability 1-day rainfall event, to examine impacts on the water table in areas across the United States. The research sought to answer: How does the water-table respond to EPEs? Results showed that water-table response was affected by soil properties such as porosity, and by saturated hydraulic conductivity. Results also showed that the recovery of the water table could last over 2 years depending on the soil type. This work was followed up by a modeling project that examined different intensity and duration EPE scenarios, such as those that occur as a result of atmospheric rivers. This work has implications for communities looking to extract water when water tables are high as well as implications for low-lying areas that may be flooded by rising water tables after EPEs.

Claudia used her Graduate Fellowship Award to travel to Lee Vining, CA in the Summer of 2022 to learn more about the Mono Basin watershed and how humans have affected the surface water-groundwater interactions of Mono Lake. Claudia has a life-long connection with the Mono Lake Committee, having previously been part of their outdoor experiences program in high school and a summer intern in college. Claudia toured the Mono basin with hydrologist Mr. Peter Vorster and Executive Director Geoff McQuilkin, to explore where water may be flowing into and around the Lake. The purpose of the visit was to get a field understanding of the basin so that Claudia could later create a model to understand

Picture of Mono Lake and its precipitation station outside of Lee Vining, CA, looking southwest towards the Sierra Nevada. Black volcanic dust is seen on small sand dunes.
photo credit: Claudia Corona

groundwater flow pathways. During the field reconnaissance, Claudia visited the areas around the lake where precipitation, streamflow, and groundwater level data was collected, as well as areas where reservoirs and man-made channels exist for water withdrawal for local use and exportation out of the basin. Claudia aims to write a post-doctoral proposal to continue working on this project after graduation.

Brie Corsa was awarded an NSF Postdoctoral Fellowship and will start with the California Volcano Observatory in August.

Brianna Hibner (with the help of Tyler Lincoln), collected three cores using a vibracore in locations around Bermuda, where the seafloor used to be covered in halimeda. Halimeda is a calcifying green macroalgae that has been found the be quite sensitive to changes in its environment. With the acidification of the ocean, these halimeda are likely to produce less calcite or less robust calcite (easily degradable). In December of last year, Brianna submitted 5 halimeda calcite sediments from varying depths in two of the cores to NOSAMS for radiocarbon dating through hydrolysis. She plans to use these radiocarbon dates to find a sedimentation rate for each core to see if halimeda rates are decreasing with increasing seawater temperature. Brianna also plans to look at halimeda calcite sediments in the saved cores to see if they appear less robust in the upper sections of the core as well as look for changes in preservation abundance. Knowing if these algae are already affected by climate change could put regulations in effect to further their protection. All made possible by the Penny Patterson Award.

Michael Frothingham is graduating this Spring, 2023, with a Ph.D. in Geological Sciences, co-advised by Drs. Kevin Mahan and Vera Schulte-Pelkum. Michael's accomplishments are amazing because he crossed traditional boundaries between geology and physics that are often very hard to scale in order to reach his research goals. Another reason why Michael is amazing is that he published the entirety of his dissertation (three main papers) before defending, which is a very difficult feat, and within the standard timeframe for our Ph.D. program! Finally, a third reason why Michael is amazing is that he is one of the most accomplished graduate student teachers from our department, with experiences ranging from teaching assistantships, guest lecturing, obtaining a graduate teaching certificate, mentoring undergraduate students on research projects, as well as developing, teaching and publishing a remote field course module.

Based on my time as a graduate student at CU, what I plan to carry with me onto my next chapter is an openness to reach out for help and collaboration. At its core, my Ph.D. research is about identifying the limitations within my own scientific specialization (Structural Geology), reaching out to peers with complementary abilities (Geophysics), and exploring how collaboration can address geologic questions of mountain building in a whole new light. This interdisciplinary research helped us find an entirely new branch of low-hanging scientific fruit. In my next chapter as a Geologist at the U.S. Geological Survey, I similarly plan to learn the advanced questions and state-of-the-art techniques that my peers are working on, to freely bounce ideas off each other, and to build effective collaborations that can tackle outstanding questions and drive our science to new frontiers. I never want to be afraid to ask for help.

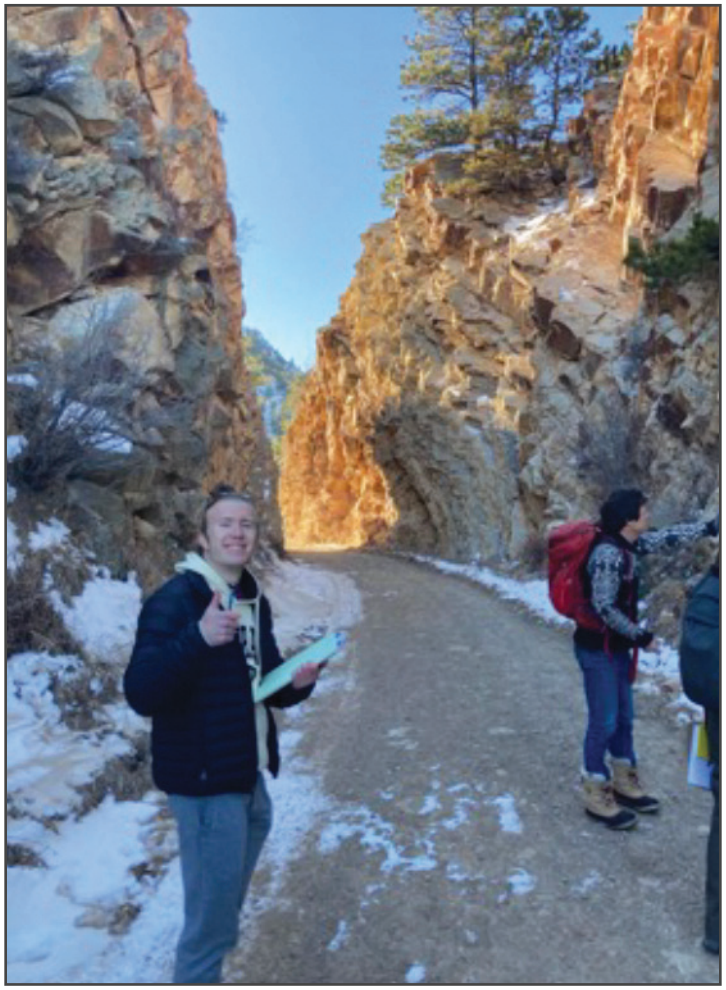
Naomi Ochwat plans to use the Penny Patterson Award to fund current and planned research including studying the glacier dynamics of the tributary glaciers in the Larsen B embayment in the Antarctic Peninsula. The glaciers are currently undergoing rapid retreat after the January 2022 fast ice break-out event. I will monitor the retreat and investigate the processes governing the responses, while connecting them to general calving and retreat theories, including

Misha measures the strike of an outcrop along the Mount Sanitas East Ridge Trail in GEOL2700

Misha Toor received the Gustafson Scholarship and Geology Excellence fund.
Misha is an undergraduate double majoring in geology and ecology because she is interested in how the biosphere and the geosphere interact to produce the ecosystems we see around us. She has worked with Dr. Kendi Davies helping to study the impacts of habitat fragmentation, and later as a lab assistant for Dr. Katie Snell and CUBESSIL. Working with Katie and her student Juliana, Misha received a UROP grant to look for magnetofossils of magnetotactic bacteria in modern sediments from the Great Salt Lake as well as the nearby Sheep Pass Formation. She hopes to help constrain the environments that these microbes live in and gain a window into how the microbial ecology of this setting has changed through geologic time.
In the coming year, Misha looks forward to working on an honors thesis with Dr. Eve Hinckley studying changing nitrogen fluxes from warming alpine soils. She is excited to apply lessons from geoscience to understand how ecosystems are changing in the Anthropocene.
Misha used funds from the Gustafson Scholarship and Geology Excellence Fund to pay tuition for the 2023 Maymester Intro to Field Geology course. Misha learned a lot about the tools and procedures that geologists use in the field and how science is communicated. Plus, She made some great friends (shoutout team Silly Sandstones!) She will be using these tools throughout her degree and later on in her career, tackling climate change and helping to address the field's complicated legacy.

Ryan Flat
This past year was Ryan Flats first studying geology at CU. He has come to love and appreciate this fascinating field. His coursework and fantastic instructors have given him a great introduction to many different facets of geology, serving as a jumping-off point for even further explorations. In this department, Ryan has also found such a close-knit community of professors, researchers, TAs, and students who care so deeply about each other and strive for excellence in their studies.

Having found his footing during this past year, Ryan plans to continue taking advantage of the many great opportunities that CU offers. Ryan is super excited to get to travel to Death Valley next semester with



the field geobiology course as well as take a topics course in carbonate sedimentology. He is also very excited to begin working on an honors thesis with the guidance of Dr. Trower. Ryan's research plans to analyze the occurrence of grapestones in ooid samples from the Great Salt Lake. Receiving the Kolber Scholarship from the geology department has helped my participation in these opportunities, lightening the financial burden of buying field gear and tuition. Ryan feels lucky to be able to study, explore, and understand some of the oldest and most interesting puzzles Mother Earth has left for us.

Isla Griston was awarded the Philip G Worchester Scholarship as an undergraduate geology major Isla anticipates graduating in Spring 2024. She started her post-secondary education at Rice University in 2020 before transferring to Las Positas Community College and later the University of Colorado Boulder. Her love for geology started with a fascination for earthquakes as a young California resident, an interest that was furthered by the introductory geology courses at the colleges she attended. Although she has not finalized her plans for after graduation, she is looking into attending graduate school in the United Kingdom where her family is from.

Spherical projection of the Benson Earth Sciences building. photo credit: Karl J. Mueller

the Marine Ice Sheet Instability and Marine Ice Cliff Instability. We intend on going to the embayment in January 2024 to collect field data on the calving behavior of Crane Glacier, using time-lapse imagery, drone photogrammetry, and hopefully bathymetry measurements. Naomi also received the GPSG summer travel grant and CIRES Innovative Research grant (as Co-PI). Naomi will be teaching on the Juneau Icefield Research Program in the summer of 2022 and doing fieldwork on the Thwaites Ice Shelf, Antarctica, in the winter of 2023.

Stephen Sheehan - Thank you for the graduate research travel grant I received last year for travel to Iceland. The benefit it provided to my research and professional development was substantial.

With the grant, I was able to rent a drone, and camper van, and purchase supplies needed for 10 days of measuring faults throughout Iceland. I traveled to various field sites and programmed the drone to capture photos along 15 prominent normal faults of interest. Using photogrammetry software I created centimeter-scale resolution DEMs, which were integral for plotting accurate fault scarp profiles. Scarp profiles were then used to test the validity of discrete element models and investigate the role of trishear fault propagation in the formation of hangingwall monoclines. Greater fault burial depth tended to drive wider trishear structures at the surface, while thinner coverage favored steeper and narrower monocline geometries.

In addition to aiding my research, this travel experience greatly enhanced my marketability as a professional geologist. It was one of the main reasons I was hired for my current job as a 3D Geologic Modeler and Mine Measurement Specialist. I've been using laser scanners to create high-resolution 3D models of surface and underground mines, which I then use for fine-scale geotechnical/structural analysis and slope stability monitoring. Very similar to the skills I gained while traveling to Iceland.

Getting a MSc from CU has been a great experience and I just want to thank you for giving me the opportunity to travel and progress my skills as a geologist.

Spencer Zeigler and **Sabrina Kainz** went to The University of Alberta (Edmonton, Canada) to work with Dr. Graham Pearson. They worked a "Selective Fragmentation" machine (SelFrag) to disaggregate over 20 kimberlite samples using electricity!
The samples will be used for apatite (U-Th)/He thermochronology in the TRaIL here in the Geological Sciences department.

Leo Zook received the T. Keith Marks Scholarship and in the Spring semester of 2023, worked as an intern at Boulder's Mountain Research Station with Dr. Noah Molotch of the geography department. During this internship program, a team would hike on skis to the C1 site and tunda lab on Niwot Ridge. They collected snow hydrology data to better understand the surrounding areas' snowpack and snow water equivalent. This data collection included digging snow pits, using federal samples, taking density measurements, identifying snow layers, measuring snow grain size, identifying snow metamorphism, and more.
This research was very enriching and educational. The Mountain Research Station staff, grad students, and professors that he worked with were all extremely helpful and made the experience wonderful. Near the end of the semester, they presented their findings at Boulder's annual Hydrology Symposium. The experience was slightly intimidating as they were the only undergraduates in attendance, but overall was very beneficial.
In Summer 2023, Leo will be traveling to Juneau, Alaska to participate in the Juneau Icefield Research Program. He will be living on the Juneau Icefield for two months. In Juneau, Leo will learn a wide array of glacial research skills. He plans to study the biogeochemical effects of glacial melt and hopes to continue this research into the 2023-2024 school year with Dr. Markle of the geology department.

Students travel to Nevada

Alamo impact breccia exposure.
photo credit: Amanda Alexander

Amanda Alexander, Carolyn Crow, and **Jenn Davis** of CU Boulder Geology travel with Simone Marchi of SwRI Boulder to Southern Nevada to investigate Alamo impact structure. The Alamo impact breccia is one of the most voluminous known outcropping carbonate megabreccia which has been identified in 20+ mountain ranges in southern Nevada. The breccia has been dated to be late Devonian in age (~385 Mya) by conodont fossils and is interpreted to be a product of a large hypervelocity impact that hit the region which was a carbonate shelf and proto-pacific ocean shoreline during the time of impact. The breccia was first inferred to be from an impact by John Warme (field trip leader and retired faculty of Colorado School of Mines) in 1991.

Jenn Davis examining large, poorly sorted impact breccia layer.
photo credit: Amanda Alexander

L - R: Jenn Davis (PhD Candidate, Dept. of Geological Sciences), Carolyn Crow (Assistant Professor, Dept. of Geological Sciences), Simone Marchi (Staff Scientist, SwRI Boulder), Amanda Alexander (PhD Candidate, Dept. of Geological Sciences and Research Analyst at SwRI Boulder).

Your generous support helps to fund many of our graduate programs and research initiatives enabling our graduate students the ability to positively impact the world around us.
Thank you!

Degrees Awarded (Fall 2022- Spring 2023)

BA Geology Majors

Muhammad Haikal Ezhar Abu Bakar
Noah Francis Belinowiz
Maximilian Accardo Carr
Lauren Elizabeth Dickinson
Adeduni Folarin
Xing Gao
Christopher Garcia
Chase Anthony Goldsberry
Erik Grossaint
Sarah Leather
Qianxi Linghu
Andreia Correia Merten
Fardeen Qasemi
Cole Cooper Rockwood
Anne M. Selvage
Maxwell Gates Sherwin
Jake Spies
Mohd Shubbli Suhaidi
Nolan Tanguma
Vu Tuan Tran
Juliana Sophia Zitron

Graduating with honors

	Advisor(s)	Thesis
Muhammad Haikal Ezhar Abu Bakar - **summa cum laude**	Dr. Tom Marchitto	A 30,000-year Thermocline Temperature Paleo-reconstruction using Mg/Ca Analysis on N. dutertrei: Implications for Eastern Equatorial Pacific Paleo-ENSO.
Andreia Correia Merten - **magna cum laude**	Dr. Karl Mueller	Morphology of the Enterprise Rupes Lobate Scarp: Implications for Structural Kinematics and Fault Scaling.
Nolan Tanguma - **summa cum laude**	Dr. Irina Overeem	T Validating Turbidity Retrieval Algorithms and Investigating Their Relation to Colored Dissolved Organic Material and Chlorophyll Concentrations in the Stikine River Delta.

MS Candidates Graduating with Degrees

	Advisor(s)	Thesis
Bernerd Richard K'aŋ P'iŋ Archer	Dr. Brian Hynek	Final Project: Strong Global Statistical Evidence for a Coupled, Active Warm Wet Noachian Mars Refutes the Late Noachian Icy Highlands Hypothesis.
Hayley Bennett	Dr. Bradley Markle	Constraining the Magnitude of Abrupt Changes in Atmospheric Circulation During the Last Glacial Period.
Cameron Chambers	Dr. Shemin Ge	Surface Deformation and Seismicity Linked to Fluid Injection in the Raton Basin.
Elize Chaves	Dr. Craig Jones	Plan II: Using Pn to identify Seismic Velocity anomalies in the Great Plains.
Jamie Aaron Glass	Dr. Lon Abbott Dr. Becky Flowers	Evidence for pre-rifting events along the Coral sea/Queensland boundary and exploration of tectonic implications for passive margin formation along the Eastern Australian coast.
Eva Nur Jorn	Dr. Karen Chin	Investigating evidence of fossil bacteria and microbially mediated carbonate precipitation in Cretaceous herbivorous dinosaur coprolites.
Elizabeth Ashley Menezes	Dr. Kristy Tiampo Dr. Anne Sheehan	Geodetic Techniques Applied Towards Understanding Induced Seismicity in the Raton Basin Colorado and New Mexico.
Teodora Maria Mitroi	Dr. Kristy Tiampo Dr. Michael Willis	Identifying global landslides using satellite imagery and machine learning in Google Earth Engine with SLID.
Carlton Mueller	Dr. Leilani Arthurs	STEM Bridge Program Structures, Administration, and Evaluation: An Integrative Literature Review.

Lydia Ann Pinkham	Dr. Aaron Bell Dr. Carolyn Crow	New Insights to Angrite Petrogenesis: An Experimental Study of Crystal-Melt Partitioning Behavior of Iron and Chromium in Angritic Magmas.
Sean Pomeroy	Dr. Carolyn Crow	Testing the Importance of Impact Shock on Resetting Lunar 40Ar/39Ar Ages Through Development of a New Multiple Diffusion Domain (MDD) Program.
Daniel Postal	Dr. Paul Weimer	Plan II: Petroleum systems of the Paleozoic strata, eastern Delaware basin, west Texas.
Stephen Sheehan	Dr. Karl Mueller	The Influence of Volcanic Resurfacing on the Growth of Normal Faults in Icelandic Rifts.

PhD Candidates Graduating with Degrees

Ciara Asamoto	Dr. Sebastian Kopf	Enzyme specific isotope fractionation in bacterial dissimilatory nitrate reduction.
Magali Barba-Sevilla	Dr. Kristy Tiampo	Seismology from Space: Source Modeling of Anthropogenic and Tectonic Earthquakes using Satellite Radar Observations.
Enrique R. Chon	Dr. Anne Sheehan	Understanding crustal stress and local earthquake detection from observational seismology.
Claudia Rebecca Corona	Dr. Shemin Ge Dr. Suzanne Anderson	Impact of Extreme Precipitation Events on the Water Table and Groundwater Recharge.
Brianna D. Corsa	Dr. Kristy Tiampo	Detection and Time Series Analysis of Natural Hazards through utilization of Optical and Radar Satellite Remote Sensing Techniques.
Michael Geoffrey Frothingham	Dr. Kevin Mahan Dr. Vera Schulte-Pelkum	Crystal to Crustal Scale Seismic Anisotropy: Implications for Continental Tectonism.
Jasmine Hansen	Dr. Kristy Tiampo Dr. Michael Willis	Detecting Land Elevation Change in the Polar Regions Using High Resolution Remote Sensing Techniques.
Rachel E. Havranek	Dr. Kathryn Snell	The expression of climate in pedogenic carbonates: using modern analogues to better understand ancient records.
Jennifer Lee Reeve	Dr. Boswell Wing	The phylogeny, physiology, and evolution of salinity tolerance in Cyanobacteria.

2023 Spring graduation ceremony

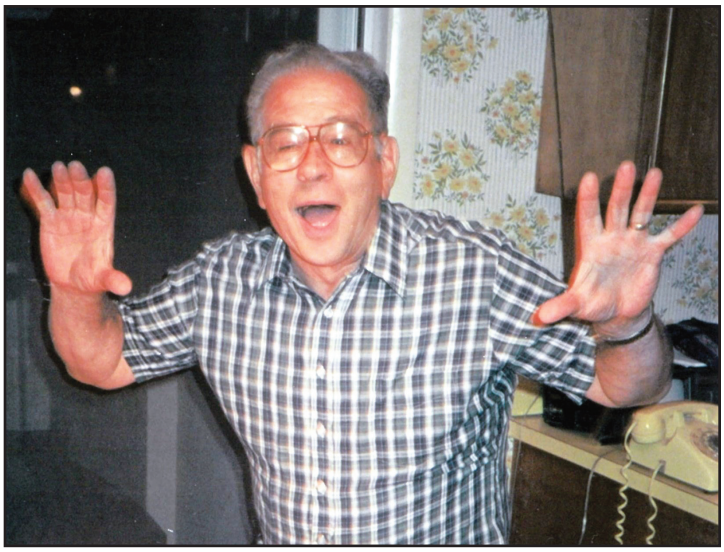
Alumni News

Kyren Bogolub, a 2021 Ph.D. with Craig Jones, has moved from the Colorado Geological Survey to join the University of Nevada's Seismology Laboratory. The position she has vacated is to be filled by 2023 Ph.D. Enrique Chon.

2023 graduate, **Elize Chaves**, who got her MS with Jones, will be joining the Bureau of Reclamation full-time at the end of May 2023.

Mark H Anders (BA, 75). I was deeply saddened to hear we lost Pete Birkeland. This occurred three months after the loss of C. Dan Miller, one of Pete's first Ph.D. students. I was a field assistant for Pete and Dan for over a month in the Wind River Mountains of Wyoming. I refer to my time with Pete and Dan as "my summer of the yellow dot". Pete was a monster hiker and even though I was just out of the Marine Corps, I was at my hiking limit keeping up with Pete. The yellow dot was the Vibram brand symbol located in the center of the soles of Pete's boots. I would see the two dots coming at me rhythmically while going up mountain trails each morning. I am sure there was beautiful scenery available – but my focus that summer was on keeping up with the yellow dots. One day Dan and I decided to beat Pete back to camp without telling him. So within a couple of miles from camp, Dan and I picked up the pace and passed Pete. Pete quickly recognized we were racing him back to camp. Without a word, Pete turned up his pace and soon Dan and I were again in Pete's dust. Both Pete and Dan were great geologists, men of character, and following them in the field was one of the great adventures of my life and led to a career as a geologist (manders@ldeo.columbia.edu).

Obituaries



The RMAG is deeply saddened to announce that Dudley Wood Bolyard, 90, a 64-year resident of Colorado, died Nov. 3, 2022, peacefully at his home surrounded by family. Born May 26, 1932, in Tyler, Texas, he and his brother Steve were raised by Garrett and Verda Bolyard in Louisiana and Oklahoma. Garrett was a geologist with Barnsdall Oil Company.

At 15, he achieved the rank of Eagle Scout and spent the next three summers as a Trail Guide at Philmont Boy Scout Ranch in New Mexico. He graduated from Classen High School in Oklahoma City, where he received the distinguished honor of "Best Physique", a title he enjoyed for the remainder of his days.

In 1953, he received a Bachelor of Science with honors, in geology, from Yale University, and his Master of Science, in geology, from Colorado University in 1956. A few weeks later, Dudley married the love of his life, Marion Mulholland. Together they raised 3 daughters: Sandra, Nancy, and Joyce in Littleton.

He was an avid member of the Yale Mountaineering Club, organizing and co-leading The Yale-Logan Expedition in the unexplored Logan Mountains within the Canadian Rockies during the summer after his junior year. Practically nothing was known about this region between the Northwest Territories and the Yukon at the time. His team was instrumental in mountaineering (summiting and naming 9 previously unclimbed peaks, though names have since been changed), exploratory work, and preliminary geologic reconnaissance in the region. After graduating from Yale, he worked to map Ellef Ringnes Island in the harsh environment of the Canadian Arctic, for the Canadian Geologic Survey. In 1956, he became a member of the American Alpine Club, a great honor.

Dudley had a distinguished career as an independent petroleum geologist. He was a past president and honorary member of the Rocky Mountain Association of Petroleum Geologists, and an honorary member of the American Association of Petroleum Geologists. He was the founder and first president of the Denver Earth Resources Library. A lifelong learner, his travels and research were a culmination of his passions including earth science, history, and politics.

He was a man of many interests, but first and foremost was his family. The Bolyards spent time together traveling and enjoying the family cabin in the Poudre Canyon. He could often be found on the

deck or out front of the cabin enjoying a glass of Jim Beam amid a steady stream of smoke, cooking steaks and hamburgers on the BBQ. Booming laughter from friends and family members usually accompanied, the clinking of glasses as they cheered to a day of adventure. Dudley enjoyed hiking, fishing, skiing, hunting, backpacking, and mountain climbing. He climbed all fifty-four 14,000-foot peaks in Colorado, including the first known winter ascent of Mount Sneffels, back in the days of solitary summits and prior to the advent of guidebooks and footpaths. He also climbed in Wyoming, New Mexico, and the Northwest Territories of Canada.

His survivors include his wife of 66 years, Marion Bolyard, their children, Sandra Bolyard and her children Kathryn and Carolyn Blehm, Nancy Bolyard (Bob), Joyce Bolyard and son Neil Rutherford, sister-in-law Jean Bolyard, nieces Susan (Rob) Gardner and Holly (Bruce) Maddox, and nephew Garrett (Molly) Bolyard.

Dudley was an avid reader and amongst his favorites was Homer's "The Oddessy", which he read too many times to count. He was enthralled by the hero, Odysseus who bravely conquered many challenges on his long voyage. Family and friends wish Dudley safe travels on his own, final epic journey. - Rocky Mountain Association of Geologists, November 2022

Sarah E. Crump, Ph.D. by Bob Anderson

The 2013 University of Colorado Eastern Baffin Island field team at Spire Camp, coring South America Lake. Sarah is in the middle, the one woman, with four men on either side.

In November 2022 we lost one of our best graduate students to cancer. Sarah Crump was a well-known graduate student in both the Department and at INSTAAR. She worked with Giff Miller on paleoclimate issues, most but not all of them involving field efforts on Baffin Island. She was forging her own path in science through postdocs that allowed her to delve into the record of ancient DNA in sediments. She was deeply involved in a paleoclimate effort on the east flank of the Tetons. And she had just landed a professorial position at the University of Utah, where she was already mentoring several students. But to all of our collective horror, she finally succumbed to cancer after a prolonged and intense battle.

In the Spring semester, a remembrance of Sarah was held at INSTAAR, attended by family, by those fellow graduate students who had known her through her science, professors here at CU, and at UC Santa Cruz where she did a postdoc, and by new colleagues at Utah. It was a remarkable event, illustrating well how much impact an individual can have on science and on the community… and how special individuals can magnify the impact.

In classes. Sarah was a star student, but we all know that, right? She helped to set the tone in a class. While she took geomechanics, modeling, and a class on the cryosphere, it was this last I remember her from most clearly. In this class, each student chose to talk about one of the great stories of Arctic or Antarctic exploration. Sarah chose Nansen and gave a knock-out summary of his great explorations. She clearly loved the history of the science and of the geography in which she did her science. And she loved its stories. She then teamed with Simon Pendleton, her fellow graduate student working as well with Giff at the time, to summarize work the two had done as a project for the class. The topic was how small ice caps grow on small-scale promontories on Baffin. These nifty little glaciers produce an incomplete record of the climate because they can only grow so large before they "top out", bleeding ice down their steep edges. These two had been engaged in the modeling of this scenario well into the night before our morning class. But the product was finished, by god. Their report was immaculate…buffed up…practically ready to publish.

I have taught a long time. It is indeed rare to have someone so buoyant, so articulate, so good, and so elegant, in a class…

In the lab. I let Giff talk about this, as he obviously had a seat closer to the front of the class on this. But I did get to collaborate with Sarah on a project or two. I am in a position to talk about her lab work and about her writing. Lab work first. The meat and potatoes of Sarah's work, at least at the beginning of her Ph.D., was the use of 10Be to deduce the timing in the Baffin landscape. Briefly, this works this way. 10Be is a very rare isotope of Beryllium that can only be made by the impacts of very high-speed particles that ultimately

come from supernovas in the galaxy. If that particle hits an Oxygen atom in the lattice of a mineral, say quartz which is SiO2, and hits it perfectly, it generates 10Be plus some other shards. So every quartz grain in the granites of Baffin – or the Tetons, or …wherever… -- serves as a clock. All you have to do is measure how many 10Be atoms there are in the quartz, and knowing the rate at which they are produced you can assess how long that rock has been exposed to the cosmic rays. Pretty nifty idea, right? But let me give you a sense of how rare these 10Be atoms are. The rate at which 10Be accumulates on Baffin Island is about 20 atoms per gram of quartz per year. That is 20 atoms out of 1/60th of a mole, which is 6x1023 atoms. That translates into 1 out of every 1022. That's about how many stars there are in the universe. Still pretty hard to wrap your head around, right? Here is another image. If instead of atoms we are talking about grains of sand, then 1022 grains of sand would fill the state of Colorado knee-deep. One grain of that pile of sand is changed every year. The reason to know this is that making these measurements is difficult. You have to be precise, organized, patient, and careful. And Sarah was brilliant at it. Her numbers, hard-won as they were, were beautiful, and they allowed her to focus on the interpretation of the ages, ultimately telling us about the history of the glaciation in Baffin…

OK, to the writing. I was just browsing over the weekend to try to bring back those moments, leafing through Word files, and modeling files. With many graduate students you start with this pretty ratty piece of writing and beat on it first with sledgehammer-like tools, finally bringing out the finer rasps and sandpaper. But with Sarah, I never had to get out that sledge, hardly ever had to bring in the rasp. It was already in great shape. Meaning you could focus on the science. She really had a remarkable ability to express herself in writing as well as in speech.

The Brown Palace

I had the pleasure of watching Sarah in the role of graduate student representative of the department in a fund-raising event in a swanky downtown Denver hotel (the Brown Palace). I believe this evening event was pretty early in her time at CU, perhaps in her 2nd year. We all know she simply had a stunning presence. But I had not heard her speak in a setting like this. After a few dignitaries had given their typical patter, it was Sarah's turn. She stepped up to the podium, and she absolutely captured the room, packed with faculty, donors to the department, and CU dignitaries. She spoke with passion, with the command of someone far older than her age would imply, as she described her science, her trajectory as a student, the importance of equity, and of communicating climate change. There could be no better spokesperson for the department. I recall whispered questions from others – do you know her? Is she like this all the time? To which I learned to answer: Yes she is.

The Utah trip

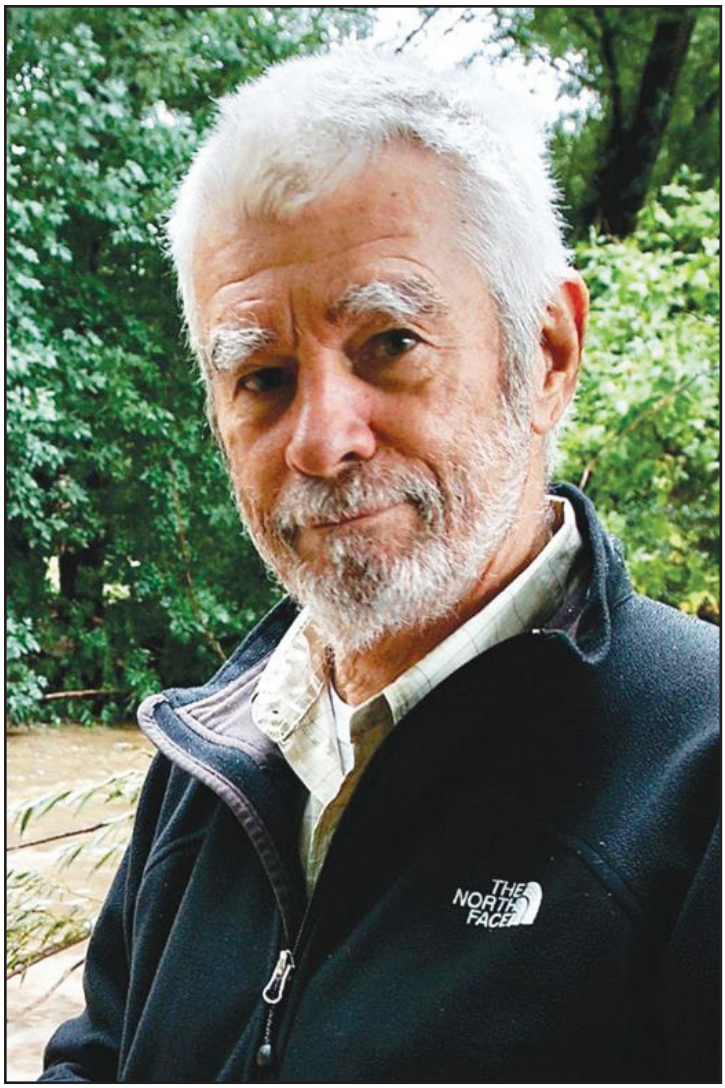
OK, one last story. I run a 4-day field trip to the center of Utah for my geomorph class. It is the crowning jewel of the class. I basically take the students to the desert and let the landscape do the teaching. We have to drive in a caravan of several vehicles, and I have had the privilege of entraining grad students in the broader arena of geomorphology to help drive these vehicles as an excuse to spend 4 days in Utah. So it is not uncommon to have had a few grads on each trip. They set a mature tone. They help to mentor the undergrads. They add to the depth of the fireside stories. In 2017 Sarah and several of her friends from among the grads in the department came along.

One of our hikes takes us to the top of North Caineville Plateau through the one 5-m wide slot through the 50 m thick sandstone formation that defines the cliffed top of the plateau. There is a register up there that records the frequency of visits… and I think we dominate the number of people. 5-10 per year, plus my class. So it is a special place indeed. We stop for lunch at the overlook, sitting at the cliff top overlooking the Henry Mountains to the south. The image I have in my head from this trip, etched but not recorded on film, is sitting at that overlook eating my cheese and crackers, and drinking my Gatorade, while Sarah did yoga on a flat rocky outcrop just to the left to us. It was one of those poses in which she is in a handstand, and her legs were bent in a perfect rectangle, one pointing horizontally, the other pointing down… and perfectly still, perfectly still… for a long long time. Again, the word elegance.

So, I have these images of a strong, elegant, confident, curious, caring, and giving woman. She contributed beautifully to the experiences of everyone around her, from her professors to her peers to her students. A star… and indeed a supernova.

The Sarah Crump Graduate Fellowship Fund has been established "To honor the life and academic legacy of Sarah Crump with graduate fellowships for students at the CU Boulder Institute of Arctic and Alpine Research whose research will support equity for underserved communities in Arctic science."

To contribute to this fund, please go to this site: https://giving.cu.edu/fund/sarah-crump-graduate-fellowship-fund



Peter Hale Molnar, Peter Hale Molnar, Distinguished Professor at the University of Colorado Boulder, died on 23 June 2022 in Lyons, Colorado. The recipient of the 2014 Crafoord Prize in Geosciences, he was a leading figure in the transformation of geology into a quantitative science. He was exceptional in the breadth of the fields he covered, which included plate tectonics, climate, seismology, tectonics, and geomorphology. He made profound contributions to the understanding of global tectonics and of the influence of tectonic processes on climate. Throughout his career, he insisted that geological phenomena, although often superficially complex, must in their essence be physically simple.

Born on 25 August 1943 in Pittsburgh, Pennsylvania, Peter had exceptional tenacity in all he undertook, which he attributed to both parents. His mother had a ruptured cerebral aneurysm when Peter was two, and his father had to take two jobs to pay the medical bills. An experimental physicist who eventually became executive vice president of Bell Labs, his father instilled in Peter rigor, respect for data, and the merits of simplicity. His mother's steadfast support, despite severe pain and partial paralysis, was echoed in Peter's support for countless younger colleagues.

Peter obtained a degree in physics from Oberlin College in 1965 and a PhD in geophysics from Columbia University in 1970. His Ph.D. was supervised by Jack Oliver, Bryan Isacks, and Lynn Sykes, and although it centered on plate tectonics, Peter became convinced that the field, then only a few years old, was stagnating, and he looked elsewhere for interesting questions. He soon found evidence that whereas the oceans obey the rules of plate tectonics, continents do not. The alignments of relative motions during major earthquakes had provided pivotal evidence that oceanic plates are rigid. In contrast, the major earthquakes in Asia show no such alignment. Instead, their principal axes of strain reveal a coherent pattern, such as would be expected if Asia were a deformable continuous medium.

Peter and Paul Tapponnier, in a collaboration starting in 1974, combined satellite imagery with meticulously reevaluated seismic data to show that deformation across most of eastern Asia represents a coherent response of the continent to India's penetration into its southern margin. The nature of the deformation depends on the elevation of the land surface: The high Tibetan Plateau is becoming thinner while its lower-lying surroundings are thickening. Peter argued that continents behave as fluids, flowing under gravity. Tibet is the pressure head that transmits, to the rest of Eurasia, the force that India applies to its southern margin. By making geological observations on scales of hundreds to thousands of kilometers and inextricably linking those observations to the underlying physics, that work demonstrated that the dynamics of continents are fundamentally different from those of the rigid oceanic plates.

At around the same time, a belief began to grow that the onset of the ice ages was caused by the rapid uplift of mountain ranges. Peter showed that this belief was based on the uncritical acceptance of it by some climate scientists, of misinterpretations by some geologists, and of data that were poor-to-false measures of surface uplift. That episode led Peter to focus on two questions, which were to preoccupy him for the rest of his life: What processes caused the global cooling that occurred in the past few million years, and what is the influence of large mountain ranges on the climate system?

Peter's modus operandi, once he had identified a problem, was to assemble a diverse group of talented (often early-career) scientists and initiate a meeting, preferably among mountains, to thrash out the means of a solution. The approach would lead to a string of papers with Peter's name buried in the middle of multinational lists of authors. It led to our present

understanding of the Asian monsoon and to many other advances in both tectonics and climate. As a result of Peter's influence, many fields of geology—an observational science when he began his career—are now pursued in a rigorous and quantitative fashion.

Peter's door was always open, and he responded with excitement to any new result; an insight that particularly pleased him would elicit a stentorian "Holy cow!" that startled all in earshot. Visitors would leave his room usually smiling, often somewhat stunned, and always armed with scribbled equations and an extensive reading list drawn without apparent effort from Peter's encyclopedic memory. Those discussions could move a nascent study to a level that the visitor had not envisaged, and for which Peter would decline credit.

Peter had a formidable exterior, but behind it, as even the newest collaborator found, was someone who enjoyed a glass of wine and a laugh. He relished the scenic and cultural opportunities that arose from studying tectonics all over the world and rejoiced in a large circle of friends and colleagues from around the globe. Peter faced cancer with his characteristic composure and tenacity, enjoying the mountains around his home for as long as he could, listening to classical music, and finishing papers. He sought tectonic beauty to the end and completed a final trip to the Galápagos Islands with close family and friends a few days before he died.

by Philip England & Roger Bilham; Physics Today

In Memoriam

Michael E. Addison (Geol'59; MA&S'63)

Dennis J. Anderson (Geol'58)

John M. Baldessari (Geol'58)

Dudley W. Bolyard (MGeol'56)

Robert D. Bonham (Geol'56)

Alfred R. Conroy Jr. (MGeol'60)

Craig D. Cowdery (Geol'80; ChemEngr'81)

Sarah E. Crump (PhDGeol'19)

Mary Christenson Eberle (Geol'69; MA'83)

Paul T. Harrold (Geol'55; MMath'63)

Allen W. Holmes Jr. (MGeol'55)

William M. Kastner (Geol'56)

Roy C. Kepferle (Geol'50)

Donald C. Koenig (Geol'57)

Lester J. LaFountain (PhDGeol'73)

Ernest F. Lombardi (Geol'60)

Stephen A. Manelski (Geol'77)

John H. Miller Sr. (Geol'57)

James W. Nylund (Geol'57)

Thomas L. Prather (PhDGeol'61)

Barbara Leigh Rees (Geol'51)

John W. Trammell (MGeol'62)

The Peter Molnar Endowed Scholarship by Karen Chin

Sara Neustadtl is not a geologist. Nevertheless, she has hiked with geologists in the Himalayas, dined with geophysicists in France, and gazed at volcanic landscapes with geoscientists in the Galapagos. She has also hosted countless geologists from around the world in the home she shared with her late husband, Department of Geological Sciences legend, Peter Molnar. Peter was a pioneering and world-renowned geophysicist and he and Sara shared more than forty years of geology-focused travel and adventure. Sara made Peter laugh and grounded his brilliant mind with great food, music, and art.

Both Peter and Sara appreciated the diversified global community of scientists they socialized with, but were dismayed to notice the low levels of diversity in the geoscience community in the U.S. Peter was considering ways to address this issue in our Department when he fell ill in 2021, and the Department and the global geoscience community are still mourning his passing. However, Sara is continuing Peter's dream to help diversify the geosciences. She donated funds from their estate and worked with her family and Department chair Bob Anderson to set up the Peter Molnar Endowed Scholarship. This is the inaugural year for this scholarship which will support undergraduate transfer students who enroll in the Department of Geological Sciences. Sara hopes that the funds will help increase the Department's diversity by providing a way for more students from diverse backgrounds to find their way to a career in geosciences.

Peter Molnar mentored many grateful geoscientists, including me. I will always treasure the support and friendship I received from Peter and Sara. The Department is thrilled that Sara spearheaded the establishment of the Peter Molnar Endowed Scholarship; these funds will allow Peter and Sara to continue contributing to the vibrancy of the geoscience community.

Peter & Sara

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